Materials Engineering in Product Design & Manufacture

Materials & Methods

September, 1954

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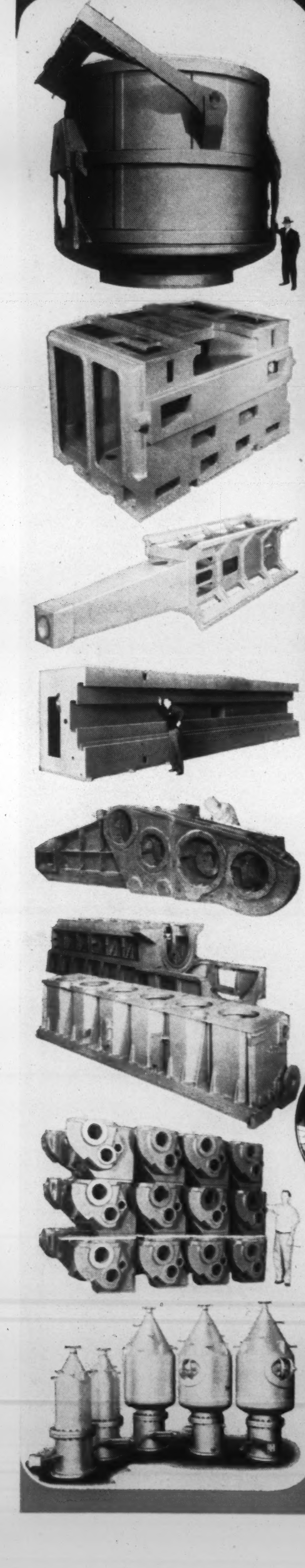

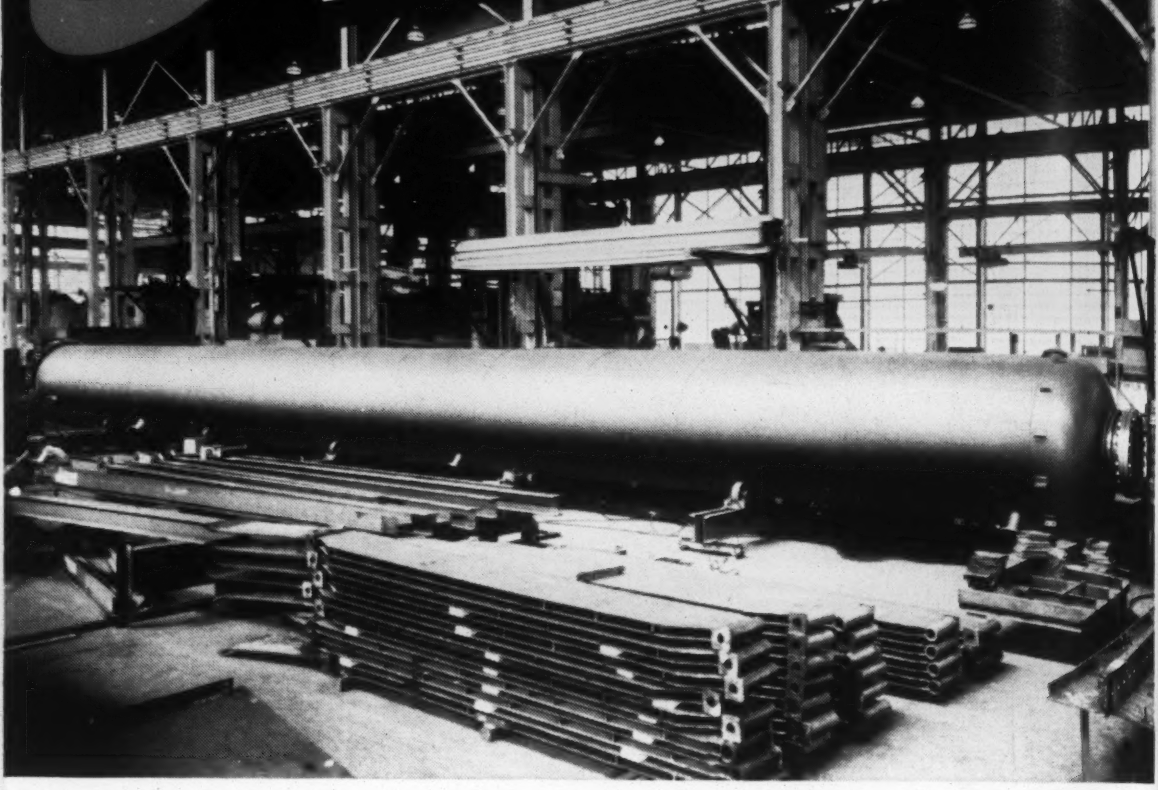

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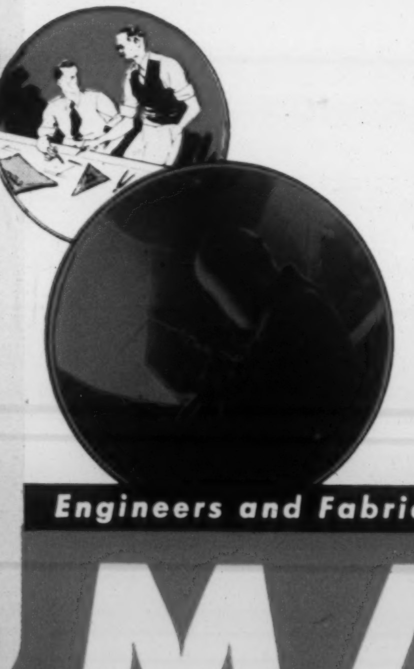

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hips

the Radiant Tube Problem

Fabricated Inconel averages nine months' longer service in comparative tests of radiant W-tubes for roller hearth bright annealer

What life can you get from fabricated Inconel radiant tubes? The figures at the right speak for themselves. But here's a bit more on the service conditions.

The place: a large steel company. *The work:* bright annealing steel tubing. *The atmosphere:* slightly reducing. *The temperature:* 1725° (much higher in tube firing leg.) *The fabrication:* designed, formed and welded by Brown-Hutchinson Iron Works, Detroit 11, Michigan.

Perhaps Inconel would improve furnace equipment life in your plant, too. This high strength alloy is remarkably resistant to oxidation at high temperatures and to corrosive furnace atmospheres. It lends itself to a wide variety of designs and is readily fabricated.

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REPORT ON LIFE OF "W"-TYPE RADIANT FIRING TUBES

Number of Tube	Location in Furnace	Wall Gage	Life Record of Previous Tube	INCONEL	Condition at End of Test
1	No. 2 Furnace N.S. No. 5, Top	.125	24 months	38 months	Still OK
2	No. 2 Furnace N.S. No. 6, Top	.095	10 months	Failed after 36 months	Removed
3	No. 4 Furnace S.S. No. 9, Top	.125	20 months	38 months	Still OK
4	No. 4 Furnace N.S. No. 5, Top	.125	25 months	33 months	Still OK
5	No. 4 Furnace N.S. No. 7, Top	.095	26 months	Accidentally damaged at 11th month	Scrapped
6	No. 4 Furnace S.S. No. 10, Top	.125	29 months	31 months	Still OK
7	No. 4 Furnace N.S. No. 6, Top	.125	23 months	Failed after 31 months	Removed

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Polyethylene tape being irradiated. (All illustrations courtesy General Electric Co.)

Electron Bombardment Produces New Plastic— Irradiated Polyethylene

by JOHN B. CAMPBELL, Associate Editor, Materials & Methods

Now available in limited quantities in form of tape . . . Many properties of ordinary polyethylene improved.

● ORDINARILY, POLYETHYLENE is a thermoplastic. When bombarded by high-energy particles, however, it becomes an infusible material. This, briefly, is the significance of "irradiated polyethylene", a new material now undergoing industry evaluation.

The first commercially available irradiated polyethylene is Irrathene 101, developed by General Electric Company's Chemical & Metallurgical Division. Irrathene 101 is only lightly crosslinked to preserve the flexibility and toughness of the conventional plastic. It is produced by electron bombardment. The electron beam is obtained by removing the tungsten target from a standard million-volt resonant transformer-type x-ray machine and replacing it by a thin stainless steel window which allows the beam to escape into the air. In large-scale production, higher-voltage machines would probably be used.

At the present time, Irrathene 101 is available only in the form of tape, and only in pilot plant quantities. The tape is 0.005 in. thick, 1 in.

Background of a New Material

In the past two years there has been a crescendo of scientific interest in the effects of high-energy radiation on the properties of thermoplastics. There are several different reasons for such interest. One is that irradiation offers a new technique for theoretical study of the nature of polymers. On a more practical level are the need to evaluate materials for use in atomic power installations and the possibility of beneficial changes in properties that might broaden applications for nonmetallics.

Results of these scientific investigations show that one of two things may happen to thermoplastics that are irradiated: they may crosslink or they may degrade. These effects are permanent. What happens to some of the most common plastics is shown in Table 1.

Of the materials that crosslink, polyethylene has attracted the most attention. Its favorable combination of physical, chemical and electrical properties has made it potentially one of the most important nometallic materials available for both consumer and industrial applications. The prospect of being able to eliminate the disadvantages generally associated with a thermoplastic material and yet retain its useful properties unimpaired is irresistible.

The exact mechanism of the crosslinking in polyethylene is still subject to debate. In effect, however, hydrogen atoms are knocked off the polymer chains leaving active free radicals which join to form a three-dimensional network of carbon-to-carbon bonds. The displaced atoms are removed in the form of a gas.

The amount of crosslinking is proportional to the radiation dosage. Actually, it takes only a small amount of crosslinking to alter considerably the properties of polyethylene. According to Charlesby, only one bond change per 1000 carbon atoms greatly changes the properties of polyethylene, and 5000 bond changes may be caused by just one high-energy particle collision. Charlesby, in his work at the British Atomic Energy Research Establishment in Harwell, used a dosage unit corresponding to about 50 million roentgen units. It took just 0.05 such units (producing about 0.5 crosslinks per molecule) to convert polyethylene to a material that would not melt and was virtually insoluble in all usual organic solvents at elevated temperatures.

The exact dosage required for minimal crosslinking depends upon the molecular weight of the polyethylene. Lawton and his associates at the General Electric Research Laboratory, who carried out their investigations with resonant transformer-type cathode ray equipment, found that the critical dosage varies inversely with the 1.31 power of the molecular weight. They also found that, although crosslinking efficiency varied among polymers, it was not affected by changes in dosage rate nor by any changes in temperature between —100 and 380 F.

Conventional polyethylene "melts" when its crystalline regions are destroyed. These crystalline regions also melt at about the same temperature in irradiated polyethylene, but the crosslinks hold the molecules together and a flexible, amorphous material with certain rubber-like properties is formed. The modulus of elasticity of lightly irradiated polyethylene drops off with increasing temperatures up to about the melting point of conventional polyethylene. Above that temperature it increases, following closely the behavior predicted by the theoretical formula for amorphous, rubber-like elasticity. The modulus of elasticity of irradiated polyethylene at temperatures above the usual melting point also increases with the amount of crosslinking and, therefore, with the radiation dosage. Extremely high dosages, on the order of 20 units, produce a material which is hard and glass-like, even at room temperature.

Not all evidence on the effects of even small amounts of radiation is on the plus side. Surface oxidation occurs when polyethylene is irradiated in air, and experts appear to disagree on the extent to which such oxidation may adversely affect certain mechanical properties.

So far, the properties of irradiated polyethylene seem to be independent of the nature of the high-energy particles. Neutrons from an atomic pile, pure gamma particles from cobalt 60, x-rays, beta rays and electrons have been used. The choice is an economic one. In addition to differences in cost of the sources, different penetrating abilities must be considered. For example, high-energy electrons have relatively limited penetration and would be suitable primarily for thin materials, whereas gamma radiation is much more penetrating and would be suitable for thicker materials. Basing his calculations on some rough but apparently reasonable assumptions, Charlesby recently estimated that the cost of irradiating polyethylene on a full commercial scale by use of fission products might be on the order of five cents a pound.

Both materials producers and product manufacturers are exploring the possibilities of plastics irradiation. Many of them are taking advantage of the facilities offered by the High Voltage Engineering Corp., Cambridge, Mass. This company, primarily a supplier of high-voltage equipment, is currently renting its own experimental radiation facilities by the hour and has just recently installed a continuous belt conveyor that feeds plastic shapes under the electron beam.

wide and comes in 36-yd rolls. Other sizes and forms are being developed but, in the near future, the material will probably be available only in forms such as film and lay-flat tubing that can be passed more or less continuously through the electron beam.

Table 1—What Happens to Polymers when Irradiated

Polymers that Crosslink	Polymers that Degrade
Butadiene-acrylonitrile copolymers	Cellulose
Chlorinated polyethylene	Polyisobutylene
Chlorosulfonated polyethylene	Polymethyl methacrylate
GRS rubber	Polymonochlorotrifluoroethylene
Natural rubber	Polytetrafluoroethylene
Neoprene	Polyvinyl chloride*
Nylon	Polyvinylidene chloride
Polyacrylic esters	
Polydimethylsiloxanes	
Polyesters	
Polyethylene	
Polystyrene	
Polyvinyl acetate	
Polyvinyl alcohol*	
Silicone rubber	
Styrene-acrylonitrile copolymers	

**Listing tentative.*

Table 2—Stress Cracking Characteristics

Corrosive medium (77 F)*	Days for conventional polyethylene to crack**
Acetic acid	1
Cyclohexane	3
Chlorobenzene	20
Triton x-100 (10%)	3
Triton x-100 (100%)	3
Acetone	2
Toluene	22–100
Ligroin	30
Silicone oil	1
Carbon tetrachloride	50
Methanol	1–3
Linseed oil	70

* *Bell Laboratories Crack Resistance Test.*
** *In each case Irrathene 101 failed to crack in 100 days.*

Table 3—Compression Set at 302 F

Dosage, 10^6 roentgen	Compression Set, %
5	45
7.5	26
10	13
15	4

What is New

Here is how Irrathene 101 differs from conventional polyethylene:

1. It has no melting point. Irradiation converts polyethylene from a fusible thermoplastic that melts about 230 F to a thermoset material that will char and burn if it gets hot enough, but will not melt.

2. It exhibits no stress-cracking. Ordinary polyethylene often cracks when it is exposed under stress, either internal or applied, to various chemical environments, such as soaps, detergents, solvents, organic acids, etc. As the results of the Bell Laboratories crack resistance test in Table 2 indicate, Irrathene 101 showed no cracking after 100 days in any of a dozen environments ordinarily destructive to conventional polyethylene. General Electric reports further that it has never been able to crack a sample in this test at room temperature, even in the most active chemical environments.

3. It holds its shape at elevated temperatures (except as noted below). As Fig 1 indicates, the strength of irradiated polyethylene decreases steadily with increasing temperature up to 230 F (110 C) at which point the curve levels off and shows a residual strength of 100-200 psi up to at least 390 F (200 C). This residual strength gives the material "form stability", i.e., the ability to hold its shape when under no load or under very light loads at elevated temperatures (provided the material is strain-free and lacks preferred orientation). According to General Electric, irradiated bottles of 4-6 oz capacity containing a high-boiling liquid can be heated to 300 F without deforming.

4. It is elastomeric at elevated temperatures. Under an applied load, it deforms only a certain amount, after which it does not continue to flow appreciably. When the load is removed the material recovers almost completely. The relationship between stress and strain at elevated temperatures is shown in Fig 2, and compression set values at 302 F are given in Table 3.

5. It may have improved dielectric strength at elevated temperatures. Dielectric strength of conventional polyethylene is reported to drop off rapidly at elevated temperatures. The improvement produced by radiation may be only apparent, since dielectric strength of conventional polyethylene is difficult to measure above 230 F.

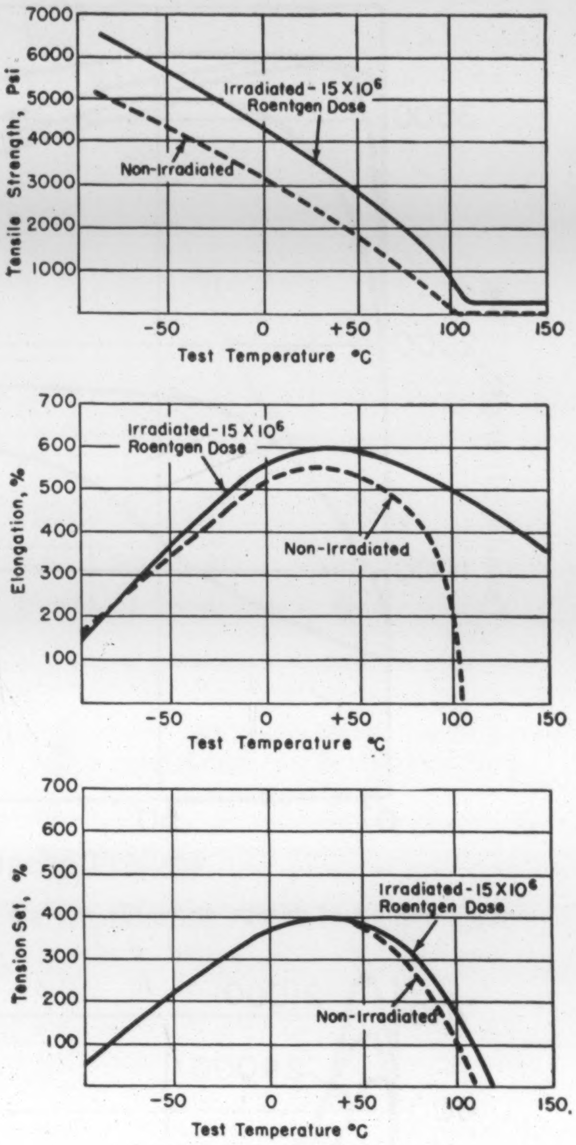


Fig 1—Effect of temperature on tensile strength, elongation and tension-set of irradiated and non-irradiated polyethylene (molecular weight: 21,000).

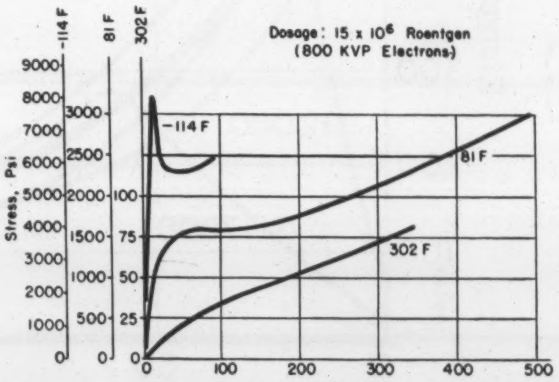


Fig 2—Stress-strain relationships for irradiated polyethylene (molecular weight: 21,000) at various temperatures.

6. It has better solvent resistance at elevated temperatures. Solvent absorption at room temperature is only slightly less. At elevated temperatures Irrathene 101 swells badly but does not dissolve in chemicals that dissolve conventional polyethylene.

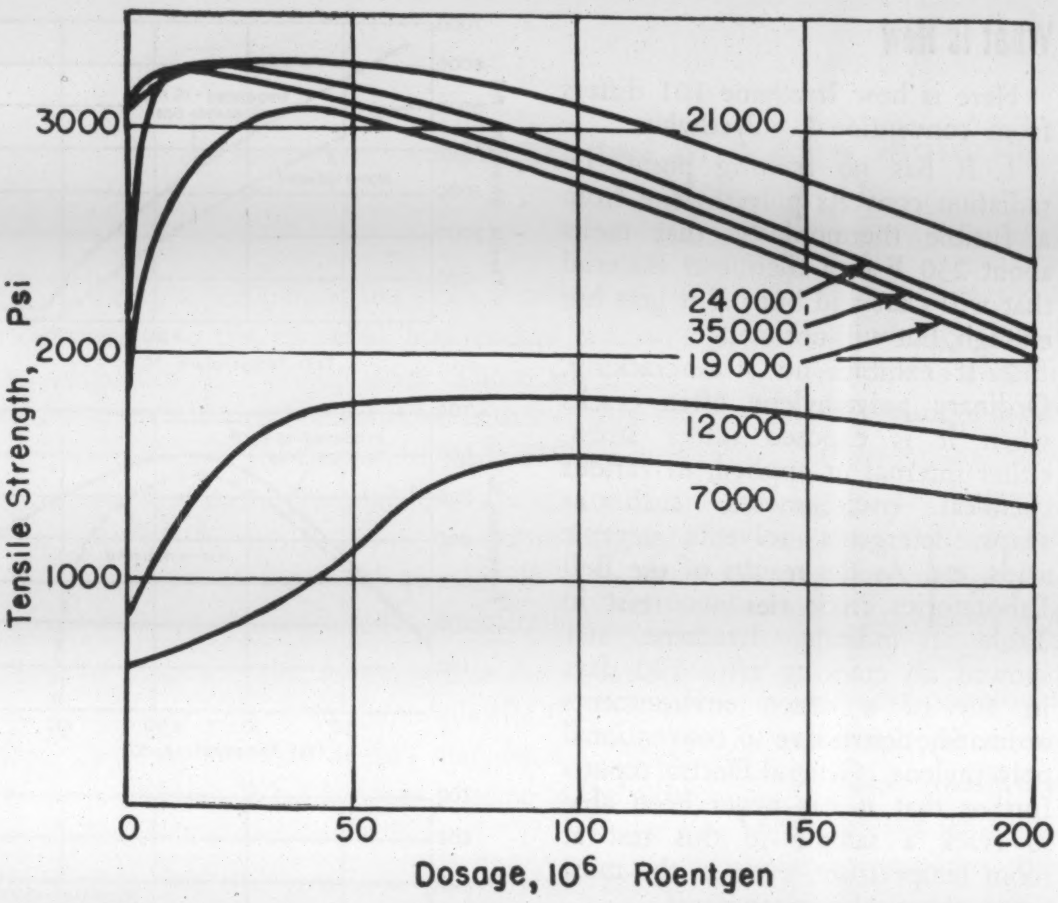


Fig 3—Effect of dosage on tensile strength of polyethylenes of various molecular weights.

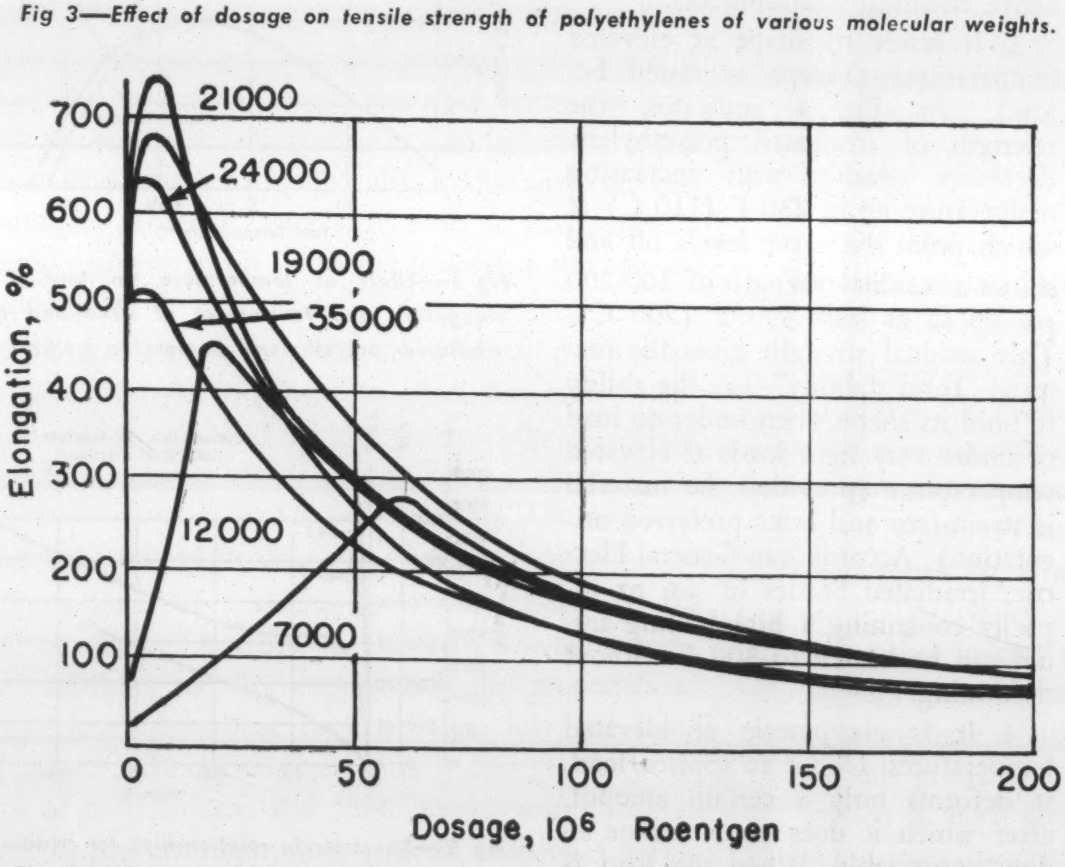


Fig 4—Effect of dosage on elongation of polyethylenes of various molecular weights.

Unchanged Properties

In most other respects, irradiated polyethylene does not differ significantly from conventional polyethylene. Here are some of the most important:

1. It is not much stronger or tougher at room temperature. The relationship between radiation dosage and tensile strength is shown in Fig 3 and the relationship between dosage and elongation in Fig 4.

2. It is not any more resistant to heat aging. Like the conventional material, irradiated polyethylene oxidizes when exposed for long periods at elevated temperatures. Without surface protection, Irrathene 101 is not recommended for continuous use above 220 F. According to General Electric, a phenolic-base varnish provides suitable surface protection for higher temperatures, but no details are available at this time.

Another Angle

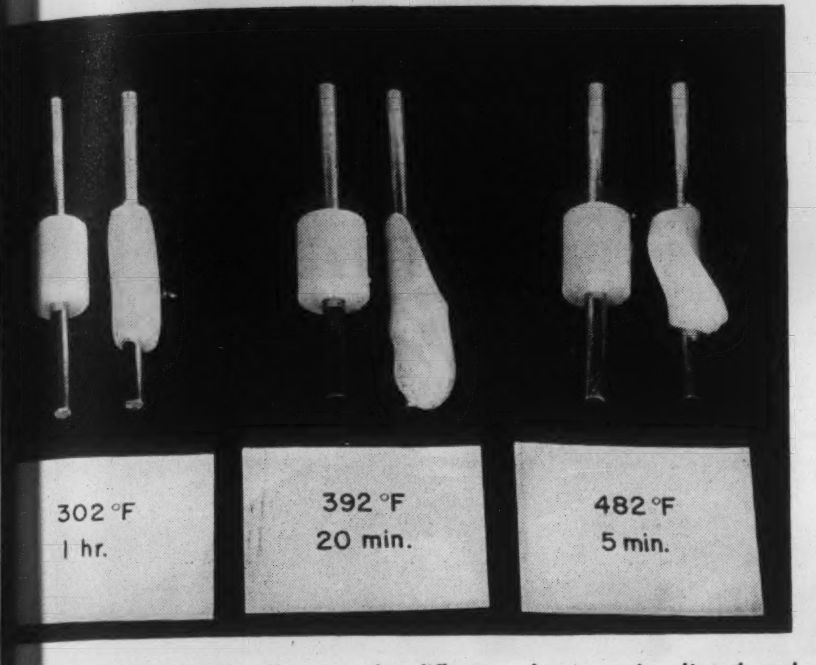
This article is about what happens to the polymer, polyethylene, when it is subjected to radiation, but what happens to the monomer, ethylene, may have even a greater economic impact in the future.

The process now used for the polymerization of ethylene gas requires pressures of up to 35,000 psi and careful control of the generated heat to keep temperature from running away. The result is tremendously expensive process equipment.

However, Prof. J. J. Martin and his associates at the University of Michigan are now evaluating the properties of small quantities of polyethylene that have been produced by means of pure gamma radiation at room temperature and a pressure of only 1000 psi. Prof. R. D. Bretton, at Yale University, is studying this problem from a more theoretical viewpoint. The use of electron bombardment is also being quietly explored.

Judging from the effects of radiation on conventional polyethylene, it is likely that polyethylene produced by radiation would have somewhat different properties than polyethylene produced by current commercial processes.

3. It is not any more dimensionally stable at elevated temperatures (except as noted previously). Irradiation, at least in practical dosages, does not "freeze" orientation or strains in fabricated parts. For example, polyethylene tape is somewhat oriented as a result of the extrusion process and, therefore, shrinks when heated. Irradiated tape also shrinks. Although irradiation crosslinks the molecules while they are oriented, the crosslinking is of such a low order that the molecules are still able to return to a random pattern upon heating. Similarly, internal strains resulting from the



These rolls of tape illustrate the difference between irradiated and non-irradiated polyethylene tape.

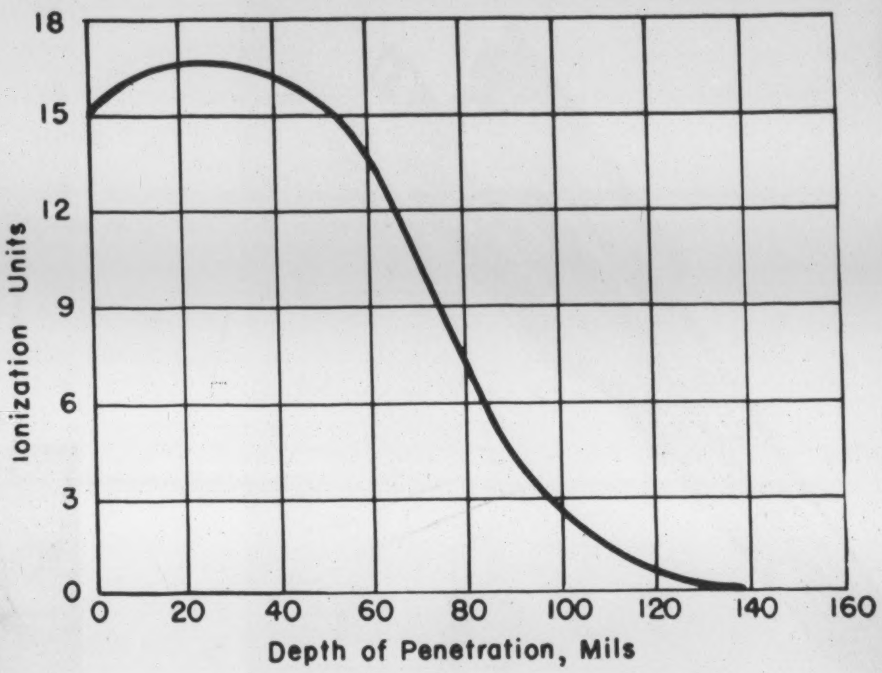


Fig 5—Ionization curve showing penetration of 800 KVP electrons in polyethylene.

molding process are relieved upon heating, and injection-molded irradiated parts warp just as do conventional parts. Blown bottles that have been irradiated have complete form stability upon heating because they are free of internal strains.

Other physical and electrical properties of irradiated polyethylene are given in Table 4.

Limitations

Irradiated polyethylene has some important limitations:

1. It cannot be injection molded or extruded, since it is a thermoset material. At present, it must be irradiated in its final form or as a fabricated part. This means each different product to be made of irradiated polyethylene would require its own irradiation and handling setups.

2. It is presently limited to thin cross sections. Depth of penetration, and hence the effectiveness, of an electron beam depends upon voltage. This is illustrated by the ionization curve for the standard General Electric million-volt x-ray machine in Fig 5. The curve for a more powerful machine would be similar in shape but on a different scale.

3. It is not likely to be available in a broad range of colors, since many dyes are affected by irradiation. Transparency and translucency, however, are not affected by radiation.

4. It is presently an expensive material. The irradiation process requires a large financial investment in equipment. Since the process is hazardous, the primary equipment, expensive in itself, must be heavily shielded and elaborate precautions must be taken for the protection of operating personnel. The high cost of equipment and protection means that low material cost can be attained only by a high production level.

Table 4—Typical Properties of Irrathene 101

Tensile Strength, psi	1800–2200
Modulus of Elasticity, psi	18,000–20,000
Ultimate Elongation, %	500–600
Rockwell Hardness	R11
Specific Gravity	0.92
Water Absorption	Negligible
Flammability	Slow burning
Acid and Alkali Resistance	Excellent
Solvent Resistance	Good below 140 F. Badly swollen by hydrocarbons and chlorinated compounds above 140–210 F.
Sunlight Resistance	Poor
Dielectric Strength, v/mil (5-mil film)	
S/T 77 F	2500
S/T 122 F	2300
S/S 77 F	1800
S/S 122 F	1800
Power Factor (60-10,000 cycles)	<0.0005
Dielectric Constant (60-10,000 cycles)	2.3
Insulation Resistance, megohms (80-100 mils)	>20 x 10^6

Applications

Applications are expected primarily where the excellent electrical properties, moisture resistance, toughness and other properties of conventional polyethylene are required along with form stability above 210-230 F or outstanding resistance to stress cracking. Examples are packaging which must withstand steam sterilization or cooking temperatures, and electrical insulation for continuous exposure to Class A temperatures or short exposures at 300-390 F. Ability to use polythylene film or tape for hotter electrical applications would probably make possible a reduction in size of some equipment with resulting economies and improved operating characteristics. Irrathene 101 is now being evaluated for such applications.

General Electric has indicated that it will announce shortly a stabilized form of Irrathene suitable for continuous exposure to air at temperatures up to about 250 F. Such a material would further broaden the possibilities for irradiated polyethylene.

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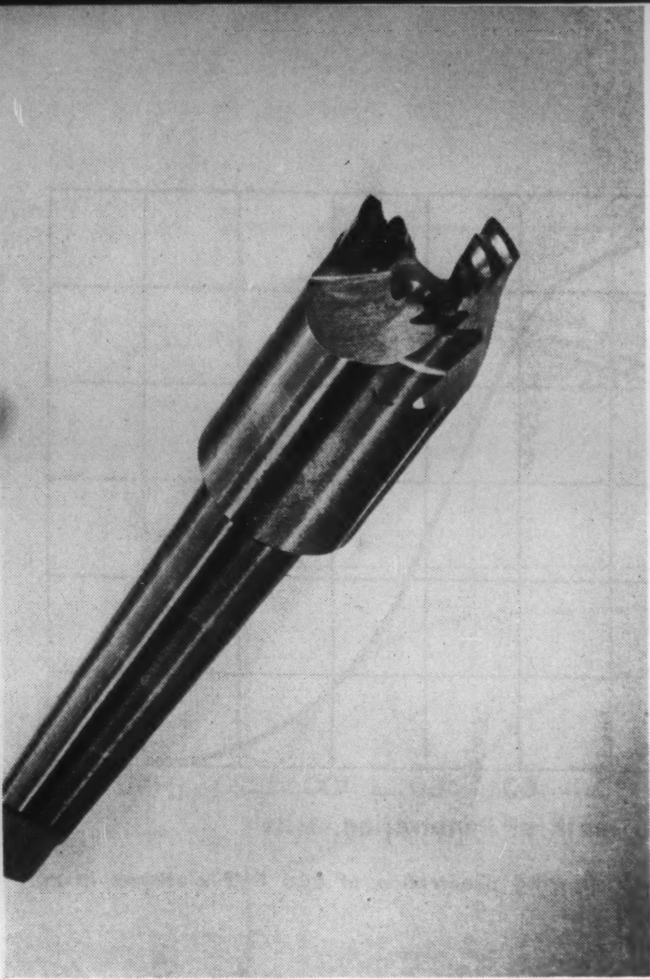
Sulfurized 6-6-2 form tool used in backing-off operation. (Photos courtesy Spiral Step Tool Co.)

Backing-off end cam relief cutters with 6-6-2 sulfurized form tool.

New Sulfur-Bearing Tool Steels

—A NEW MATERIALS PREVIEW

Service case histories demonstrate improvements achieved over conventional types.

● Working on the theory that the sulfides in free-machining steels act as internal lubricants in improving machinability, metallurgists of the Latrobe Steel Co. investigated the effect of sulfur additives on tool steels. As a result, they have developed a number of sulfur-bearing high alloy tool steels which are giving excellent service as gear hobs and in a number of other difficult tooling operations.

In preparing these sulfurized tool steels, sulfur is added in controlled quantities during melting to form alloy sulfides which are distributed throughout the steel in the same manner as the carbides. Initial development was limited to the molybdenum-tungsten 6-6-2 grade of high speed steel known as M-2, but success with this grade led to the development of other sulfurized grades in both high speed and high carbon-high chromium die steels. Latrobe is now producing these sulfurized steels in most of its high alloy tool steel analyses.

Laboratory tests have shown that the properties of these steels are not adversely affected by the sulfur content. Bend tests made on regular and sulfurized M-2 at a hardness level of Rockwell C65 gave similar strength and deflection values in both the transverse and longitudinal directions for both steels. Unnotched Izod impact strengths on sulfurized M-2 at a hardness level of Rockwell C 66 average 42 ft-lb which compare favorably with 39-ft-lb obtained on regular M-2 at the same hardness level. Cutting-edge strength was also unaffected in laboratory tests. There is no difference in heat treatment procedure for hardening these steels.

However, the service performance of a steel is the major criterion in determining its suitability. Under a number of severe service tests, the life of the finished tool made of the new steel was better than that of tools produced from conventional high speed steels. A number of case histories show the improvement obtained by substituting these sulfurized steels for regular steels.

Case 1

Part: Side Milling Cutter

Operation: Turning with carbide tipped tools, depth of cut 0.125 in., feed 0.008 to 0.10 in.

Old: Maximum permissible speed with molybdenum-tungsten 6-6-2 stock was 350 to 385 sfpm.

New: Speed with sulfurized molybdenum 2-8-1 stock increased to 746 sfpm, there was no evidence of tearing and the microinch finish was twice as good as that obtained previously.

Case 2

Part: Side Milling Cutter

Operation: Form relieving using a roughing cut of 0.002 in.

Old: Using Molybdenum-tungsten 6-6-2, it was necessary to sharpen the form tools eight to ten times to complete the operation and considerable tearing occurred.

New: Using sulfurized molybdenum M-1, the form tool required sharpening only once. The excellent finish obtained permitted the elimination of a hand finishing operation. Over-all saving amounted to 1¾ hr per milling cutter.

Case 3

Part: End Cam Relief Cutters (see photos)

Operation: Back-off operation

Old: Form tools had to be resharpened after each operation when molybdenum-tungsten 6-6-2 was used, even though the steel had been heat treated to improve its back-off characteristics.

New: Nine similar cutters made of sulfurized molybdenum-tungsten 6-6-2 steel were backed-off without resharpening the form tool.

Case 4

Part: Hob

Operation: Backing-off

Old: When backing off regular molybdenum-tungsten 6-6-2 hobs, a form tool of molybdenum-tungsten 6-6-3 high speed steel needed resharpening after six hobs were produced.

New: Using sulfurized molybdenum-tungsten 6-6-2, 55 hobs can be produced with a similar tool before resharpening is necessary.

Case 5

Operation: Drilling 1¾-in. deep blind holes in 4140 steel, using a ⅜-in. diameter drill with a 118-deg drill point. Cutting oil: 1 to 20. Hardness of steel 285 Brinell.

Old:	**FEED-IN.**	**SPEED-FPM**	**HOLES DRILLED**
0.85C, 4Cr, 2V, 8Mo	0.005	57	29
	0.007	57	12
	0.007	45	38
New:			
Sulfurized 0.85C, 4Cr, 2V, 8Mo	0.005	57	38
	0.007	57	18
	0.007	45	49

Which Method for

Hot?

"In deep drawing titanium, cost factors very definitely favor hot drawing."

by **RALPH G. GILLESPIE,** Brooks & Perkins, Inc.

● Because titanium is structurally similar to magnesium, techniques for working the two metals should be similar. This is the premise on which Brooks & Perkins worked in developing a process for the hot deep-drawing of titanium. The procedure has been employed in the forming of commercial titanium grades RC-55 and RC-70 and the alloy RC-130A.

Tooling for deep drawing is the same as that used for processing magnesium. The temperature required for the satisfactory drawing of RC-55 is about the same as that for magnesium, but somewhat higher temperatures are required in forming RC-70 and RC-130A. Speeds suitable for magnesium work well with titanium. Pressures, however, are higher since titanium is a stronger metal than magnesium. For lubrication, colloidal graphite serves in the deep drawing of both metals. If colloidal graphite is used, galling offers no difficulties and it appears that this material is the best lubricant available for forming titanium whether the operation is performed hot or cold.

In forming commercial titanium, RC-55 and RC-70 can be treated alike with the exception that the latter requires about a 100 F rise in temperature to compensate for its higher strength. Ease of forming with either of these materials depends on the severity of the draw, the thickness of the material and the capabilities of the tools. To form RC-130A the temperature must be raised further but care is necessary to avoid heating into the range in which embrittlement occurs because of absorption of nitrogen and oxygen.

By following these procedures, it has been possible to complete deep-draws in one operation which had previously required multiple draws. Titanium can be deep drawn more readily than brass, aluminum, or steel.

A cylinder hot drawn in one operation from 0.025 in. gage RC-55 is illustrated. The cylinder is 3 in. in

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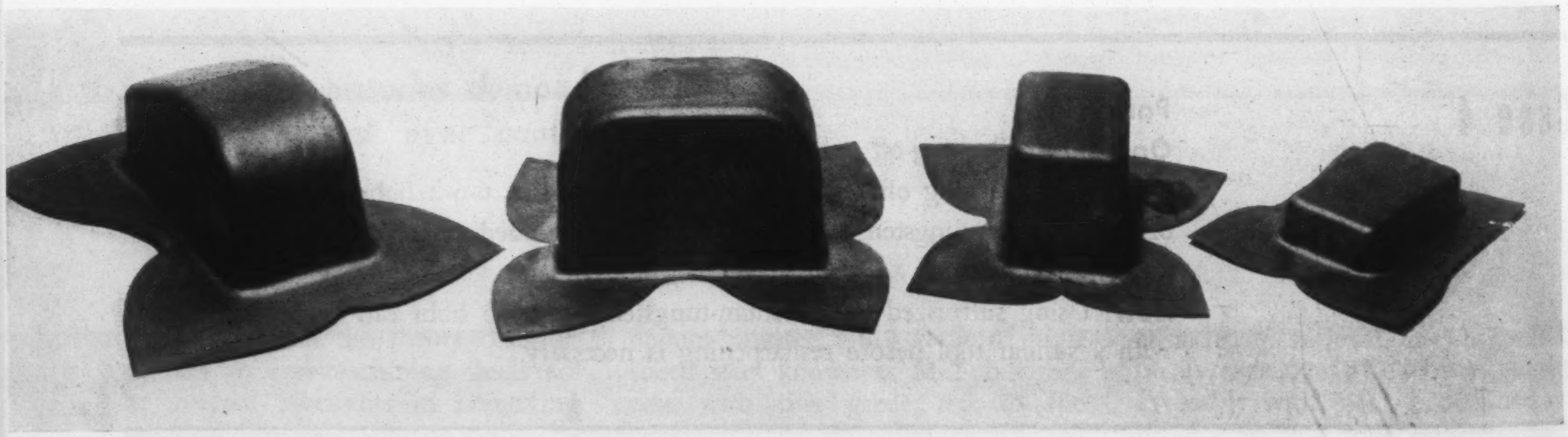
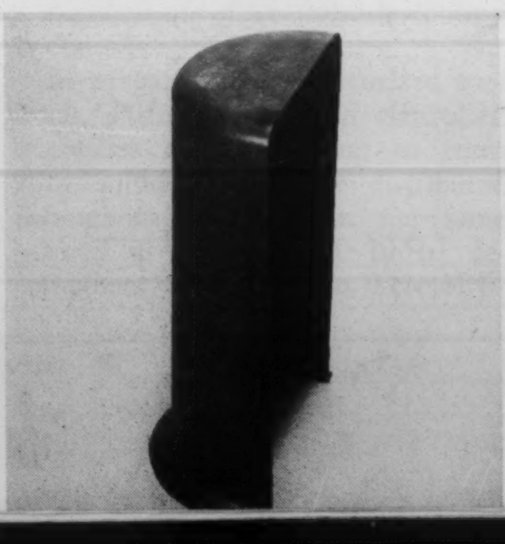
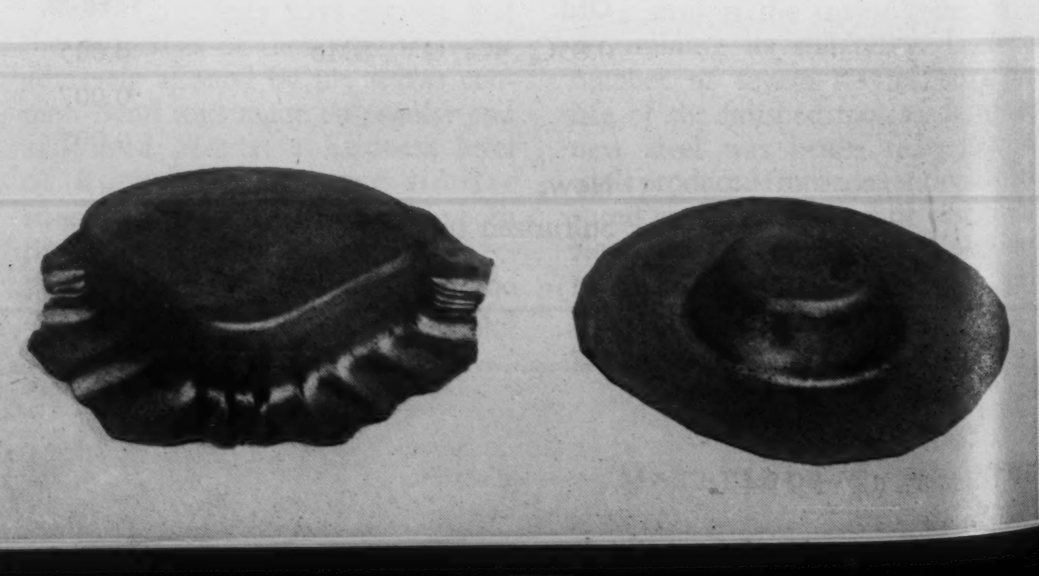


Commercial titanium parts hot drawn in one operation from 0.040, 0.062 and 0.64-in. stock.



Cross-section of a hot deep-drawn RC-55 titanium cylinder, 0.025 in. thick, 3 in. in diameter and 5 in. deep.



The first two parts drawn hot from RC-130A. Metal thickness was: left 0.042 in.; right 0.045 in.

Deep Drawing Titanium . . . Cold?

"... the various cost factors still favor working at room temperature."

by J. WALTER GULLIKSEN **Worcester Pressed Steel Co.**

Commercially pure titanium is sufficiently ductile to be deep drawn at room temperature using conventional methods. The major problem in drawing operations is the tendency of the metal to gall and score. Parts which have been deep drawn at Worcester Pressed Steel Co. have been of sufficient variety to prove the feasibility of handling commercial titanium in this manner.

Deep drawing is basically a matter of controlled plastic flow for the metal being drawn must be stressed beyond the elastic limit, but not in excess of the ultimate tensile strength. Therefore a rather critical balance must be maintained between the various stresses involved. In general, metals having a fairly wide spread between yield point and ultimate tensile strength are best suited for deep drawing. Commercially-pure titanium sheet meets this condition moderately well in the annealed condition. Furthermore, it has an elongation of 20 to 30% which is a favorable factor.

In the first trials using 0.062 in. gage Ti 75A, cups 3-13/16 in. o.d. x 2-1/8 in. deep were readily drawn from blanks 6-9/16 in. dia, a reduction in diameter of 34%, using a conventional double action cam-type press. Tools were made of hardened tool steel and had been used in production for making cups of cold rolled steel. Drawing speeds in general use for steel were too fast for titanium and better results were obtained when the press was slowed to approximately half the usual speed.

Several cups were successfully drawn showing that the titanium was sufficiently plastic to take the deformation, but the surface of the cups was badly scratched and scored. It was obvious from these early tests that lubrication was to be a major problem.

Since the pressures required for drawing titanium are considerably greater than for mild steel, various high pressure lubricants including pigmented materials were tried out.

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Titanium can be successfully drawn cold on a conventional double action press although drawing speeds should be about half those used for steel.

Hot?

Continued from page 98

dia by 5 in. deep and the corner radius is 1/4 in. No difficulty was encountered in this draw and it is reasonable to suppose that had the punch been longer than 5 in., a considerably deeper cylinder could have been successfully drawn. This is an unusually deep draw for a 3 in. dia cylinder and results on this job indicate that in some cases titanium may be even easier to hot draw than magnesium.

Various parts made of RC-70 in single operation draws are shown in other illustrations. Radius at juncture of side with bottom can well be 1/4 in. or even 3/16 in. Smaller radii can be held at the bottom of a box draw than at the side corners.

Important to remember in evaluating the depth of draws and the radii possible is the fact that the parts illustrated were drawn without difficulty on the first attempts. Had the dies been made for draws of greater depth and sharper radii, more severe draws could have been made. It is impossible at this time to predict the ultimate in drawability. All that can be said now is that parts such as those illustrated can be production hot drawn in one operation.

Apparently anything that can be drawn in magnesium in one operation can be drawn in RC-55 and RC-70. Although RC-130A is more difficult to draw, progress is being made in the development of single-draw techniques.

In deep drawing titanium, cost factors very definitely favor hot drawing over cold drawing. Steel or quality controlled cast iron (Meehanite) dies are required for either process. Dies for one operation drawing (hot) are much cheaper than dies for three or more stages. One heating of material is less time consuming and less costly than the intermediate anneals required with cold drawing, and the amount of handling in process is reduced with hot drawing. The use of colloidal graphite lubricant with hot drawing eliminates the troublesome and costly scrap and rework problems which are associated with galling and seizing encountered in present cold drawing techniques. It has been our experience that when three or more cold draws are required to make a part in aluminum, the same part is cheaper made from magnesium in one hot draw. This has generally been true even though material cost has been somewhat higher using magnesium. The same principle is even more valid when evaluating relative cost factors of cold drawn *vs* hot drawn titanium.

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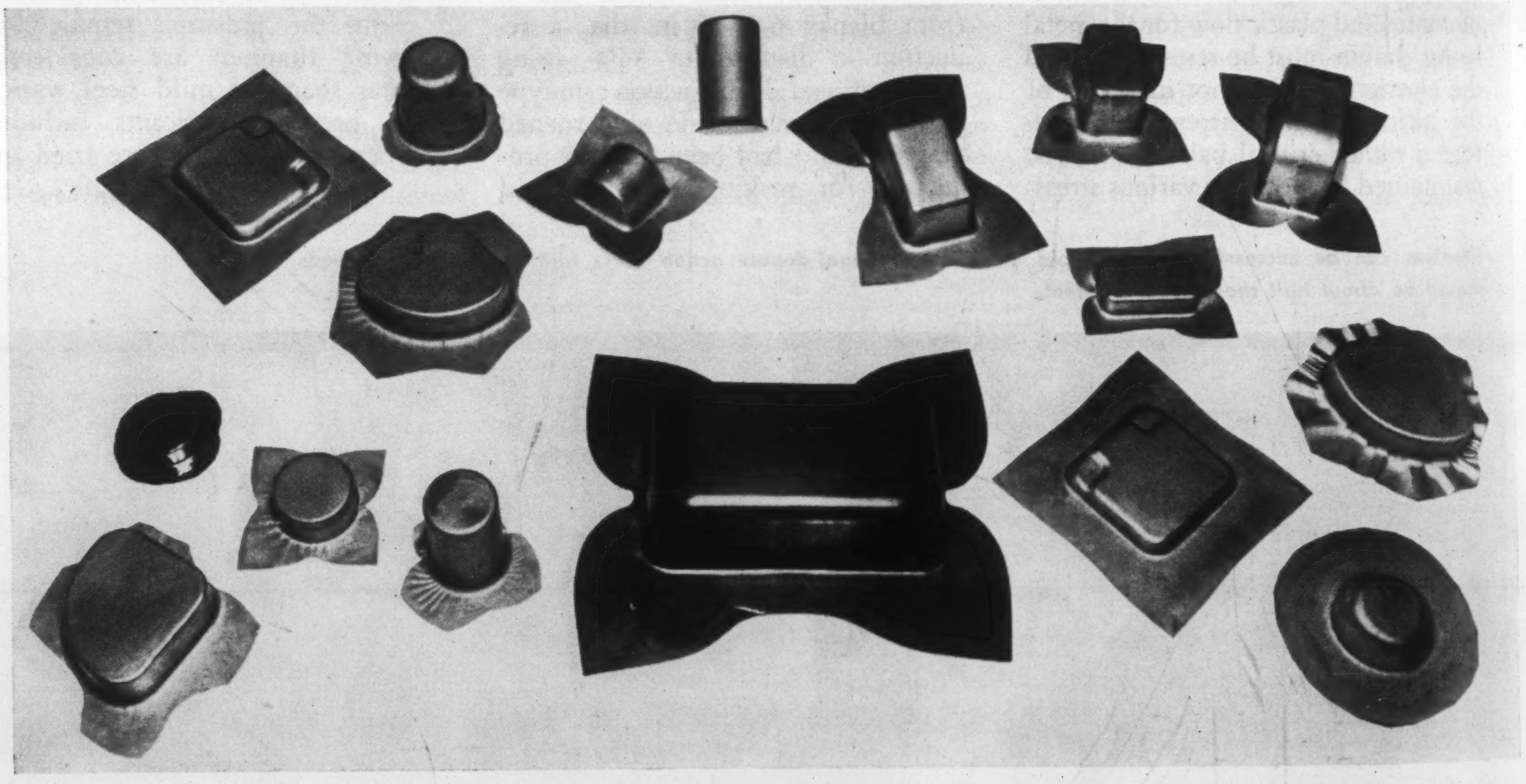
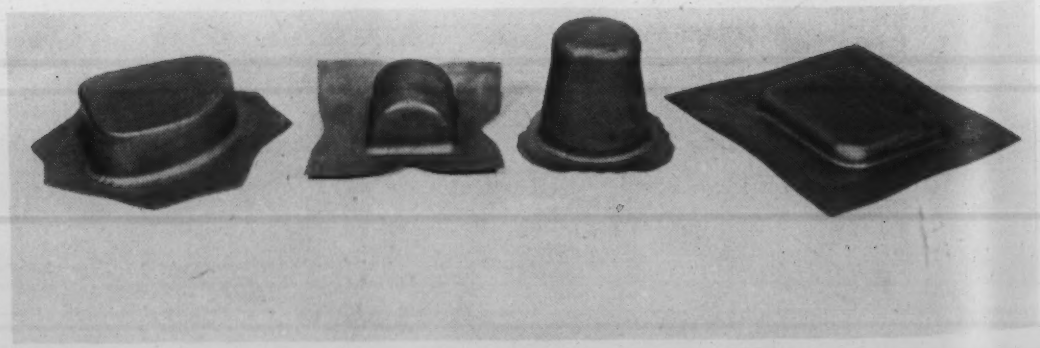


Various parts hot deep-drawn in one operation from commercial titanium RC-55 and RC-70 and titanium alloy RC-130A.



RC-70 titanium parts drawn hot in one operation. Metal thicknesses, left to right, 0.035 in., 0.035 in., 0.035 in. and 0.062 in.

Cold?

Continued from page 99

Some improvement was found, but much was left to be desired.

Phosphate coating (Bonderizing) the metal before applying the lubricant proved to be definitely helpful. The bonderizing solution used consisted of 33 lb of "Bonderite" per 100 gal of water with an addition of 7 g of sodium fluoride per gal. The temperature was 160 F and the time of immersion in the bath was 10 min.

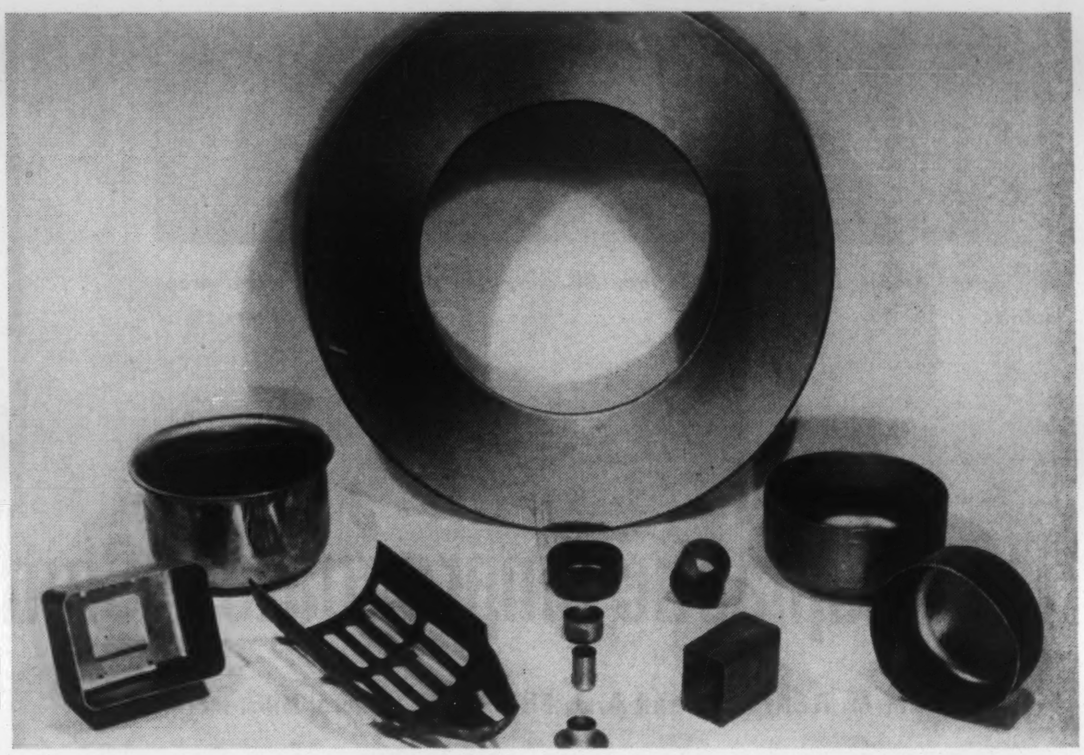
As die materials are often an important factor in galling, it was decided to explore this factor. Tests made with a set of tools having a bronze alloy die which had been used for drawing stainless steel gave results approximately the same as those obtained with the tool steel die. A chromium plated die was also tried but showed no appreciable improvement. Bonderizing proved to be essential to secure acceptable cups.

The results of primary drawing operations were sufficiently encouraging to warrant attempting successive redrawing operations, although the problem of scoring had not been solved. An oil filter case was selected which required three drawing operations followed by striking to set the flange at the open end and form the stiffening ribs on the shoulder. The center hole was punched out and the flange press trimmed after the striking operation.

Using 0.078 in. gage Ti 75A, cases were successfully produced with the same tools used for mild steel. However, the titanium work hardened so rapidly that stress relieving after each draw was necessary to restore sufficient ductility for the subsequent forming. This was accomplished by heating to 1350 F, holding for 7 min and air cooling. Stress relieving produces considerable scale; however, sodium hydride descaling is effective in cleaning the parts and restoring the original appearance.

During these tests, it was found that copper plating the blanks showed some promise in reducing frictional effects. A dry film lubricant applied on a phosphate coated surface also gave encouraging results.

Although copper plating the blanks was helpful in relieving the scratching and scoring problems, anodizing before lubrication seemed to give the best results. Blanks were anodized in an electrolytic bath consisting of sulfuric or oxalic acid at a temperature of about 60 F, using 16 to 30 volts with a time cycle of ½ to 1-½ hr—depending on the size and shape of the piece. After treatment, the parts were rinsed in clear cold running water and dried to obtain a surface ready for the lubricant.



Assortment of parts of various sizes and gages drawn at room temperature from commercial titanium RC-55, RC-70, and Ti-75A.

Because titanium work hardens rapidly when cold worked, it is necessary to stress relieve between draws. It is also advisable to stress relieve after the last draw to prevent "season cracking". A part which was not given a final stress relief is illustrated. Cracks began to develop after standing a few weeks.

Since the second and third draw dies were of sintered carbide, some experience was obtained with this die material. As might be expected, the carbide dies showed less tendency to scratch and gall than the die materials previously tried. However, the improvement was not as great as had been hoped for.

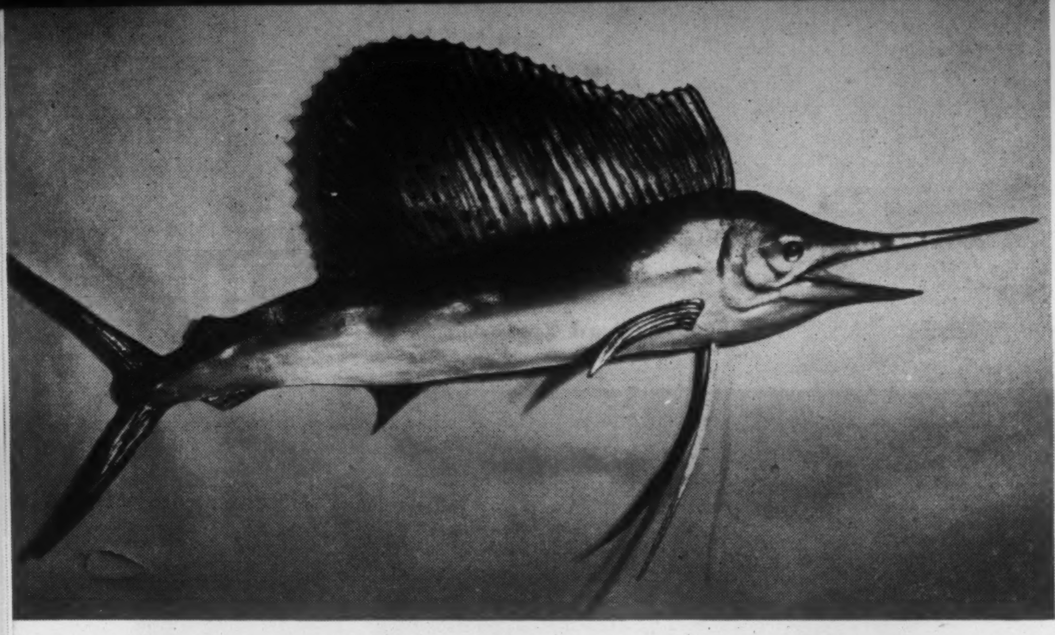
Some of the successful draws made at Worcester Pressed Steel Co. include the following: RC 70 material 0.037 in. thick was drawn into cups 2-5/16 in. o.d. x 1-1/4 in. deep—a reduction of approximately 40%. Hardened tool steel dies were used. The material was bonderized and a dry film lubricant used.

RC 70 material gaging 0.025 in. was drawn into cups 1-3/8 in. o.d. x 11/16 in. deep. After stress relief, these cups were redrawn to 1-1/32 in. o.d. x 1 in. deep. A second stress relief was followed by a third draw producing shells 13/16 in. o.d. x 1-3/16 in. deep. Other cups were successfully drawn with commercially pure titanium sheet as light as 0.016 in.

A number of rectangular boxes were also drawn. A sequence of operations involving three draws and a strike is illustrated. Parts were stress relieved between each draw.

Some question has been raised as to the value of drawing titanium at room temperatures versus hot drawing. Although stress relieving is required after cold working, the various cost factors still favor working at room temperature. Hot drawing requires more costly tooling and involves problems in handling hot blanks, lubricating, tool life, etc. Further than this, few press shops are familiar with hot deep drawing and most would prefer to use techniques permitting cold fabrication.

Additional experience will determine optimum conditions of draw radii, draw speeds, lubrication, clearances and other specific technical details which contribute to the art of deep drawing.



This 7-foot model was cast in less than 20 min, then painted with water-proof paints. *(Ben Walters, Inc.)*

This hollow mannequin was laid up over foil-covered original form. Cut in half for removal of mold, the two parts are easily rejoined with more celastic strips. *(Ben Walters, Inc.)*

Thermoplastic Impregnated Cloth—

by MALCOLM M. RENFREW and A. J. FREEMAN, General Mills, Inc.

Properties of "Celastic" Colloid Treated Fabric

		Thickness, in.		
		0.025	0.050	0.135
Weight, lb per sq ft		0.10	0.15	0.36
Density, lb per cu in.		0.031	0.029	0.027
Burning Rate, sec. per 6 in. of 0.05 in. strip		149	147	480
Water Absorption, %		36	—	—
Solvent Absorption (by weight), %		79	83	72
Shrinkage, %	warp	1.8	1.8	3.1
	fill	4.2	4.0	4.0
Tensile Strength, psi	warp	3200	2600	1400
	fill	1500	1100	900
Elongation, %	warp	3	9	7*
	fill	30	22	22*
Impact Strength (Izod), ft lb per in.	warp	5.2 } 8	6.9 } 5	1.5 } 3
	fill	4.7 } ply	4.5 } ply	3.1 } ply
Flexural Strength, psi	warp	9412	4370	2276
	fill	7033	4142	1760
Modulus of Elasticity, psi	warp	—	3×10^5	3×10^5
	fill	—	2×10^5	2×10^5
Compressive Stress (at 1% distortion), psi stress direction	thickness	17,000	21,000	18,500*
	warp	2180	3200	2210*
	fill	2810	2510	2660*
Bond Strength, psi to wood	warp	143	290	281
to aluminum	warp	67.2	217	—
Resistance to Peel, lb per lin. in. width				
Wood	warp	66.4	17.9	33.2
	fill	35.8	15.8	36.6
Aluminum	warp	10.8	16.2	—
	fill	9.0	13.5	—

** .095 in. thick grade.*

What It Is

● A FABRIC IMPREGNATED with colloidal plastic which softens on application of solvent so that the sheet can be formed by hand or with simple tools, provides an easy-to-handle material for producing light-weight, rigid forms with a minimum of mold problems. It also provides a tough, adherent, protective-coating with excellent scuff and abrasion resistance. The thermoplastic impregnated cloth, trade named "Celastic", was originally developed (and is still in use) as a semi rigid material for the toe caps of leather shoes. It is now used in many, quite different, applications.

Celastic is a colloidal precipitation of pyroxylin resin (which accounts for its toughness) plus filler and flame retardant, deposited on a base of double-napped cotton flannel. Before use, sheets of the material resemble large rolls of white blotting paper. The packed colloidal mixture picks up solvent readily, and goes quickly into solution due to the large proportional surface area of the small particles. Wet, the material is as flexible as damp cloth. When the solvent evaporates, the plastic sets, forming a homogenous, protective skin which is rigid and adheres to almost any dry surface with which it is in contact during

Plastic impregnated cloth, softened after passing through bath of thinner, is laid in position between poop deck and hatch of United Fruit Co.'s banana boat S.S. Junior. Celastic covered deck is smooth and watertight. Light color reflects heat, skin improves insulation value of deck.

cure. Due to the fine nap of the cotton flannel, the impregnated material bonds to metal, wood and glass more tenaciously than pure nitrocellulose cements.

The material is manufactured in rolls up to 50 in. wide, in 11 thicknesses, from 0.016 to 0.135 in. Laminated, it forms thicker sections. Present uses for the material include orthopedic appliances, deck covering for ships and boats, coating and repairing mold patterns, covering permanent magnets in radar sets to protect them from metal to metal shock, and display construction.

Where It's Used

Patternmaking—Patternmakers report that the plastic impregnated cloth is useful as a finishing coat on plaster and wood die forms used in sand casting. Standard woodworking tools and sandpaper are sufficient for forming the material, which provides a smooth and tough exterior coating for mold patterns and has good sand release qualities. Wooden or plaster patterns that have been dented, chipped, or accidentally made undersized can be saved by building up layers of Celastic in the damaged or undersized areas. Simple jigs or fixtures of Celastic require a minimum of skill and tools.

Design Aid—Designers have used Celastic to build models and prototypes of new products. The material shrinks slightly on curing, and will stretch drum-tight over frames of wood or metal. Several furniture designers use the material for sample models of their products.

Molding—Celastic can be molded, but it has such adhesion to all die materials that molders must exercise caution to use an effective parting agent. Generally, molds are wet down with a solution of water and detergent or sodium silicate.

Prosthetic Appliances—The easily formed plastic-fabric combination is an ideal construction material for one-of-a-kind articles, such as fitted prosthetic and orthopedic appliances. Celastic prosthetic appliances such as artificial arms and legs are light, comfortable and have good durability, which recommends them to the patient. To the orthopedic shop, the material offers the advantages of easy fabrication with a minimum tie-up of skilled labor. It bonds readily with metal, wood, cloth and leather, materials used in constructing such appliances. Artificial legs of excellent serviceability and appearance have been built with a central, load-carrying pylon surrounded by a hollow skin of Celastic.

Marine Applications — Celastic forms a watertight skin which will stand up well under wear on the decks of boats and ships. Calahan and Horsey, Inc., a New York firm holding the distribution rights for marine uses of the material, encourages its use in both repair and original construction of boats. The strong adhesion, light weight and rigidity of the plastic combined with its water and oil resistance when properly sealed, make it a versatile material for all marine repair uses. If softened with solvent which contains fungicide, it is resistant to all types of marine rot and mildew. Celastic decking has been applied to tugs, shrimp boats, ferry boat pilot houses, and very recently to the entire main deck of a United Fruit Company banana boat.

Other Uses—Celastic is a convenient home material for repair of rusted sections of car bodies, air ducts and outdoor rain gutters. Kits containing patches and solvent are on the market. Hobbyists and model builders have found a number of uses—from model railroad layouts to forming reproductions of masks and armor. Display manufacturers and theatrical scenery builders use Celastic in set construction and for building outdoor spectaculars such as large statues and parade floats. When soft, the material can be draped like fabric but will take a permanent set when the solvent evaporates. It is a good substitute for papier maché in displays exposed to weather.

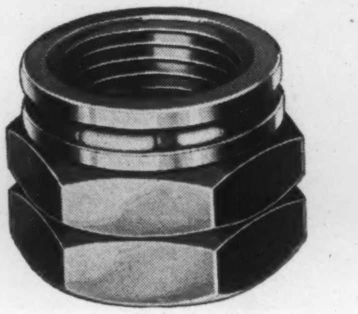
Fasteners for High Temperature Service

by **JOHN L. EVERHART**, Associate Editor, Materials & Methods

● MECHANICAL FASTENERS for high temperature applications are expected to be equal in dependability and convenience to fasteners used at room temperature. They must also withstand the special conditions resulting from the temperature. Among the characteristics required for satisfactory high temperature service are 1) sustained load-carrying ability, 2) stability under oxidizing and corrosive conditions, and 3) structural stability, with retention of original properties.

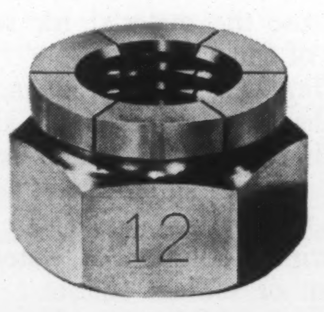
As operating temperatures increase, materials having the required mechanical properties and resistance to oxidation become less plentiful. At temperatures of 1200 F and higher, only the austenitic stainless steels and so-called super alloys have creep, stress-rupture and relaxation properties combined with the necessary resistance to oxidation and corrosion to be considered for fastening applications.

Some of these materials, however, are not suitable because they are not structurally stable over long periods of time. Resistance to shock at the operating temperature is necessary to insure satisfactory service without failure. Precipitation of carbides can cause lowering of resistance to corrosion and also embrittle the alloy. Formation of sigma phase in certain temperature ranges can also result in embrittlement. These inherent characteristics of the available materials combined with the mechanical requirements of the fastener itself lead to problems which are just being solved.



To fasten components in the GETG-190 turbo-jet engine, a nut was required which would withstand seizure and vibration at temperatures of 1200 F. This called for a self-locking fastener of new design. On the basis of all-around performance, an 18% chromium-10% nickel steel stabilized with columbium and modified with selenium to obtain free-machining qualities was selected. To overcome the galling tendencies, silver-plating was used.

In the design of the fastener finally chosen, the locking element consists of a conical section of six longitudinal segments, each inwardly offset to provide a cantilever beam pressing against the bolt and frictionally locking the nut to the bolt. The proportions of the beam are selected to keep the stresses at a level that will not result in excessive creep or relaxation at temperature. The contact area is large on the other hand to keep contact pressures low and reduce scoring tendency to a minimum. In addition, the long beams provide the elasticity required to develop locking torque at the extremes of bolt thread tolerances. (Klincher Locknut Corp.)



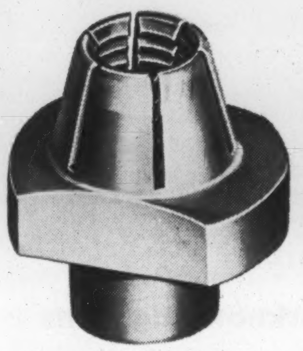
To fasten a safety switch to the afterburner of a jet engine, it was necessary that the screw head be within the afterburner and the locknut be close to the afterburner surface. In addition to withstanding temperatures of 1600 F, nuts were required to resist vibration but be capable of ready removal. Seizing and galling of the bolts was reduced by using a truncated, rather than a sharp, thread crest and a rolled or ground finish. Metal to metal contact was prevented with a chromium oxide coating. The locknut designed for use in this application is a stabilized stainless steel two-piece nut consisting of a split, threaded core keyed into a hexagonal shell. When axial motion of the shell is stopped by the assembly surface, further rotation of the nut to provide the locking torque effects a collet action forcing the core down and around the bolt. Upon wrench release of the locking torque, the tapered core is forced into the original position, providing adequate clearance for removal. (Standard Pressed Steel Co.)

Fastening Problems

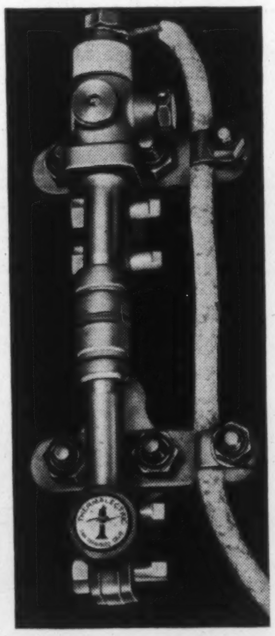
Generally, the problems of fastening at moderate temperatures are quite readily handled. But with temperatures above about 1200 F special fasteners are required, and, as mentioned previously, practically the only materials which will serve satisfactorily from the temperature standpoint alone are the austenitic stainless steels or the super alloys. These materials usually have rather low yield strengths and high coeffcients of thermal expansion which to some extent offset their desirable characteristics of good creep strength and resistance to oxidation. All of these materials also have a marked tendency toward galling and seizing at elevated temperatures and direct metal-to-metal contact under the pressures created during bolting can result in virtual welding of the components. Thus the problems of assembly, disassembly and reassembly are grave.

A number of expedients are employed to overcome galling and seizing. Silver plating is successful at the lower end of the range but as the temperatures increase toward 1600 F, this plating tends to flake off. For these higher temperatures, one producer of high temperature fasteners uses a chromium oxide coating which is said to be free from flaking and peeling, stable at operating temperatures and to have a relatively low co-

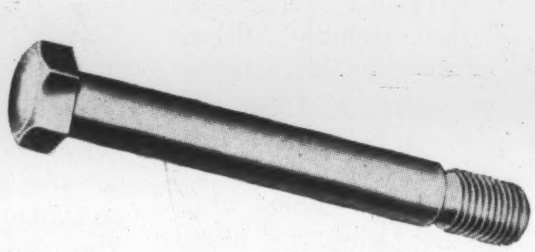
Above 1200 F, special fasteners are required. Only a relatively few materials are available to meet the stringent service conditions.



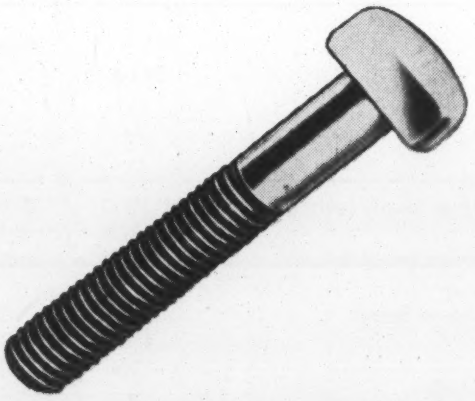
To assemble components at temperatures up to 1600 F where high frequency vibration is a factor a locknut was required which could be readily re-used. The nut is designed to reduce high stress concentration and torsional load in the first three threads and distribute the load over a greater number of threads. Locking occurs when the grooved washer is wrenched down against the work surface. (Elastic Stop Nut Corp. of America.)



A locknut was required to withstand temperatures to 1200 F for applications in exhaust manifold systems, furnaces and firewall assembies. The nut designed for this service was a stop nut as well as a locknut, that is, it locked at any point along the bolt or stud whether seated or not.
Firm locking action even under vibration is provided by the slotted top, divided into six segments, which are closed in to make the locking collar smaller than the outside diameter of the companion bolt. The spring tension resulting when the nut is applied holds the locknut securely at any position on the bolt. To overcome seizure, the nut is silver-plated. (The Delron Co., Inc.)



A Hexagon head machine bolt, ½-20 by 3.609 in. was required for use in the turbine section of a jet engine and consequently had to withstand high temperatures. Weight control to be held within ±0.01 oz. The bolt was cold headed from Discaloy, centerless ground and roll threaded. The alloy was age hardened with close control of tensile strength, harness and grain size. Bolt is used in Westinghouse J-34 engine (H. M. Harper Co.).



A slabbed head machine bolt ¼-28 by 1.484 in. was required to fasten main jet engine casings together. The bolt was produced from A-286 alloy. The one flat surface permits positioning and holding, while fastening the nut, to assure as close a bearing surface as possible. (H. M. Harper Co.).

efficient of friction. Galling and seizing at temperatures up to 1400 F have been controlled also by coating the bolt and nut with an anti-galling silver or copper base compound. By replacing the compound between reassembly cycles, galling is prevented for a reasonable number of cycles.

One of the more promising developments is the use of under-size bolting. After extensive experimenting and service testing, the aircraft engine industry has decided that the use of an undercut of 0.003 in. on the pitch diameter of the male thread of high temperature fasteners is the most effective solution to the problem of high temperature bolt-nut seizure. Self-locking nuts are available which operate satisfactorily on these bolts up to at least 1200 F in the sizes used for engines.

It must be emphasized that this solution of the problem has been adopted only by the aircraft engine manufacturers and will not necessarily be employed by airframe producers or other manufacturers of aeronautical components.

In order to assure satisfactory service with austenitic materials, definite bolting procedures are required. Because of low yield strengths, satisfactory seating of gaskets is difficult. One organization recommends prebolting with high-strength bolting materials to seat the gasket. The bolts are then backed off to about 50% of the torque required under service conditions and replaced individually by the austenitic bolts, drawn to the same load. After the bolts have been entirely replaced, the entire assembly is tightened in several steps to the service load.

It is difficult to maintain tight bolted joints at high temperatures because plastic flow occurring in bolts, gaskets and flanges is unpredictable. Thus, an over-all reduction in stress occurs and bolts must be tightened periodically to assure satisfactory operation of the assembly. Plastic deformation of the assembly, whether resulting from creep or from differential expansion between flanges and bolting, can cause failures which usually cause leakage either while shutting-down or during the subsequent starting-up period.

Fasteners

For applications in this high temperature range, fasteners are highly specialized. There are no standard designs. Fasteners for such service must be a compromise between the properties of available metals and requirements of the design.

Bolts must possess high strength and good elastic properties combined with toughness in order to insure tightness. During tightening, stresses of many thousands of pounds may be incurred and the bolt must be sufficiently ductile to resist impact stresses, without breaking threads, and also must resist excessive elongation.

Locknuts which have a special means of gripping a threaded member to prevent relative rotation between nut and bolt are essential. These nuts can be divided into two types, 1) free-running types which develop locking characteristics only after being torqued into position, and 2) prevailing-torque types which lock at any position on the bolt. There are many types of locknuts. Since they differ in the locking mechanism, they have different characteristics. No laboratory test has been devised for determining how a given locknut will perform in a specific operation and the best testing method available at present is a trial in the installation.

Since development of fasteners for high temperature service is so specialized, the best method of indicating the approach which has been used is the case history. Therefore, the accompanying case histories have been assembled to give a cross-section of the problems encountered and how they are solved.

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Wright Air Development Center

Typical Properties of Some High Temperature Alloys

Alloy Class	Temp. F	Creep Strength, 1000 psi		Rupture Stress, 1000 psi			Thermal Expansion per F (70-1000 F)	Oxidation Resistance*
		0.1%/ 1000 hr	0.01%/ 1000 hr	1000 hr	10,000 hr	100,000 hr		
18:8 Stainless Steels (wrought)	1200	7–12.7	4.5–7	—	11–17	7.5–14	10.5×10^{-6}	1650 F
	1300	4–7.9	2.5–4	—	6–10	4–7	—	—
	1500	1.2–2.8	1.0-2	—	2.5-3	2-3	—	—
25:12 Stainless Steels	1200	8	4	—	14	10	9.6×10^{-6}	2000 F
	1300	4.5	2	—	7.5	4.5	—	—
	1500	1	0.5	—	2.5	2	—	—
25:20 Stainless Steels	1200	9	8	—	12	9	9.6×10^{-6}	2050 F
	1300	5-6.5	5	—	7.5	5	—	—
	1500	1–2.5	2	—	2.5	2	—	—
SUPERALLOYS:								
Austenitic Non-heat Treatable Steels (wrought)	1200	—	—	35–42	—	—	$9.3–9.8 \times 10^{-6}$	1600 F
	1300	—	—	20–26	—	—	—	—
	1400	—	—	12–16	—	—	—	—
	1500	—	—	9–12	—	—	—	—
Precipitation Hardenable Austenitic Steels and Cobalt Base Alloys (wrought)	1200	—	—	35–51	—	—	$8.2–9.8 \times 10^{-6}$	1600–1900 F
	1300	—	—	23–38	—	—	—	—
	1400	—	—	18–25	—	—	—	—
	1500	—	—	11–20	—	—	—	—
	1600	—	—	9–15	—	—	—	—
Cobalt-Base Alloys (cast)	1200	—	—	44–47	—	—	$7.9–8.4 \times 10^{-6}$	1900–2100 F
	1300	—	—	30–40	—	—	—	—
	1400	—	—	15–26	—	—	—	—
	1500	—	—	14–25	—	—	—	—
	1600	—	—	12–17	—	—	—	—
Nickel-Base Alloys (cast and wrought)	1200	—	—	30–65	—	—	$6.65–8.0 \times 10^{-6}$	2100 F
	1300	—	—	25–45	—	—	—	—
	1400	—	—	12–28	—	—	—	—
	1500	—	—	10–20	—	—	—	—

* *Maximum temperature for continuous service.*
Note: Values are approximate and can vary considerably depending on composition, heat treatment and other factors.

Primarily an architectural material until recently, porcelain-enameled aluminum is now being considered for a variety of industrial applications. *(The Kawneer Co.)*

Why Porcelain-Enamel Aluminum?

by **B. C. BRICKER**, **Electrochemicals Dept., E. I. duPont de Nemours & Co., Inc.**

● ALUMINUM IS A SOUND and lightweight structural material. It is also an attractive material and tends to retain its pleasing appearance over a long period of time. Yet more and more engineers and designers are turning to porcelain-enameled aluminum for certain applications. Are they merely "gilding the lily"? No, the fact is that the ceramic coating contributes certain desirable service characteristics that could not be easily obtained in any other way.

This combination of properties has not long been available. In contrast to the high firing temperatures used for ferrous-base porcelain enamel, firing temperatures for lower-melting aluminum must be on the order of 1000 F. Only in recent years has a satisfactory frit for firing on aluminum been developed.

Meanwhile, the growing use of porcelain-enameled aluminum suggests that engineers and designers should seriously consider the important advantages of this material. The chief characteristics imparted by the ceramic coating are durability and corrosion resisitance, increased rigidity, thermal insulation and color flexibility.

The glassy surface is hard and abrasion-resistant. It resists alkalis and mild acids. There are field installations of porcelain-enameled aluminum which show no signs of deterioration after six years of service. Not only does the ceramic surface appear quite suitable for normal weathering, but, since it is impervious to salt water, it may broaden the use of aluminum in marine applications. In addition, the nature of the glassy surface makes it easy to clean and maintain without refinishing.

Glass in compression is strong, and the addition of a glass coating to aluminum sheet increases its rigidity. The increase in rigidity means that it is sometimes possible to reduce the thickness of the aluminum sheet to compensate for the added weight of the enamel. Substantial savings in base metal cost are sometimes possible where both faces are enameled. An average vitreous coating for aluminum weighs 10 gm per mil thickness per sq ft. Thus, on a volume-weight basis, the enamel is only 1.4 times the average weight of aluminum. If a 3-mil coating is added to 0.051-in. aluminum sheet, the increase in total thickness is less than 6%, the increase in weight is less than 10%, but the increase in flexural strength and resistance to surface denting is more than 60%.

The fire barrier offered by a ceramic coating is well known. More important for some structural applications are the thermal insulating characteristics of the enamel; it is several times more resistant to heat transfer than the aluminum. Electrical insulation is another function sometimes performed by the enamel.

The color and texture possibilities offered by the enamel are practically unlimited. The hardness and durability of the enamel surface makes the color permanent and its luster readily maintained.

The high-lead frit for aluminum has unusually high impact resistance. The enamel also resists spalling or flaking off. If it is chipped or cracked, the damage will not spread. Since there is no disfiguring corrosion of the base metal, repair is needed only where damage is extreme, as in complete deformation of a panel. Thermal shock resistance is also good. Porcelain enameled aluminum at an elevated temperature may be plunged into cold water without detrimental effects on the coating.

Porcelain enameled aluminum has excellent workability. It can be sawed, cut, sheared, drilled or punched with little or no exposure of the base metal. Raw edges show little corrosion with time and the enamel does not spall or erode back from a cut edge. The enamel can be applied over welds. With careful work, it is possible to weld a reverse face after the enamel has been applied to one face without visual damage to the coating. Porcelain enameled aluminum can also be heat treated if necessary for added strength.

These properties have led to the use of porcelain enameled aluminum in many different applications. The most widespread are architectural siding, store fronts, roofing, wall tile and ceiling panels. Others are signs and labels where color, durability and light weight count; appliances such as stoves, refrigerators, washers and driers, where reduced shipping costs are important; and electrical shielding where the high dielectric strength of the enamel and the light weight of the aluminum are a useful combination. Other applications where weight is an important factor include furniture, hardware and trim, dials and instruments, lighting fixtures, transportation equipment and sanitary ware.

This article is based on a paper presented at the 26th annual meeting of the Lead Industries Assn., April 1954, in Chicago.

Problem: To check soundness of 2000 compressor blades.

Solution: Automatic Radiography with Cobalt 60

by JACK HILE, Materials Testing Laboratory, Westinghouse Electric Corp.

● FAST RADIOGRAPHIC INSPECTION of more than 2000 compressor blades for the world's largest axial flow compressor built for the Air Force's PWT wind tunnel was accomplished by means of a unique automatic method.

To insure that critically stressed areas of the blades were free from defects each blade had to be radiographed. Cobalt 60 was selected as the source of radiation because of its low cost and its adaptability to an automatic handling arrangement. In addition, changes in section thickness in the areas radiographed demanded a greater latitude of exposure than can ordinarily be obtained with industrial x-ray equipment.

To achieve economic and satisfactory automatic radiographic examination of these blades the following were required:

1. A large cobalt 60 source on the order of 1000 millicuries to make the exposure time relatively short.
2. Radiation protection for technicians and shop personnel.
3. Proximity to the blade repair area.
4. Low installation and operating costs.

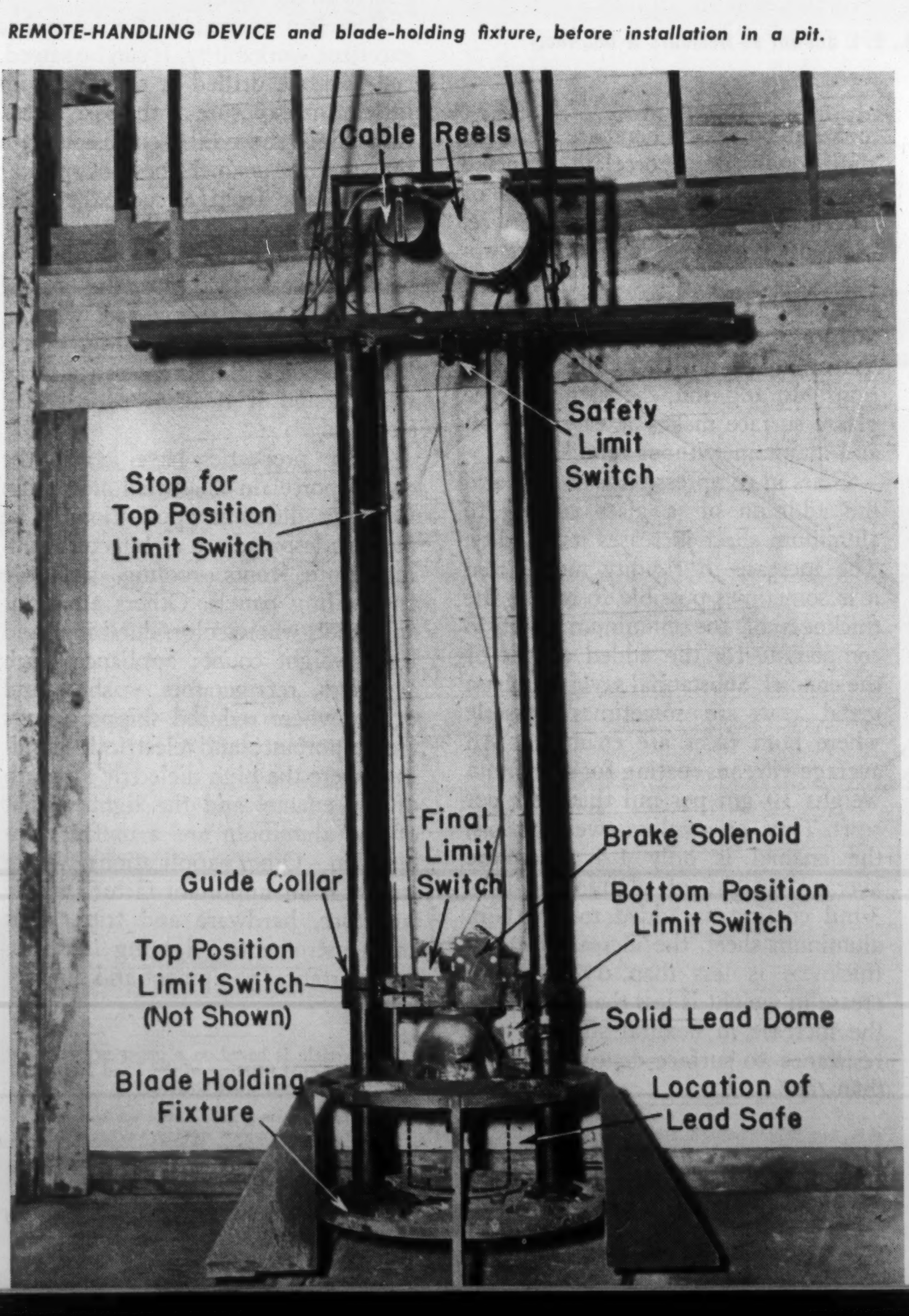
To fulfill these requirements, a blade-holding fixture and a remote-radiation-source handling device were installed in a 12-ft-deep pit adjacent to the blade repair area. Overhead crane service regularly used for blade inspection and repair was available for placing and removing blades from the pit. The blade-holding fixture holds four blades vertically for each set-up. This fixture consists of two round, parallel plates 36 in. in dia and 15 in. apart, with opposing holes to accept the blade trunnions.

How It's Done

When the mechanism is at rest, the cobalt 60 source is suspended in a lead safe between the parallel plates. The solid lead dome prevents upward radiation, and the safe prevents appreciable horizontal radiation. The radiographer enters the pit only when the cobalt 60 source is in the lead safe.

With the four blades in position, two films are placed on each blade. The film is secured by means of a strip of belt webbing and a short length of rubber tubing. After the film is positioned the operator ascends to the control panel at shop floor level. Two timers in the control panel control the exposure time at each position. With the clocks set at the proper exposure, the cycle is started with a push of a button. As the cycle starts, the lead dome moves upward with the cobalt 60 source suspended about ¾ in. below it. The

REMOTE-HANDLING DEVICE and blade-holding fixture, before installation in a pit.

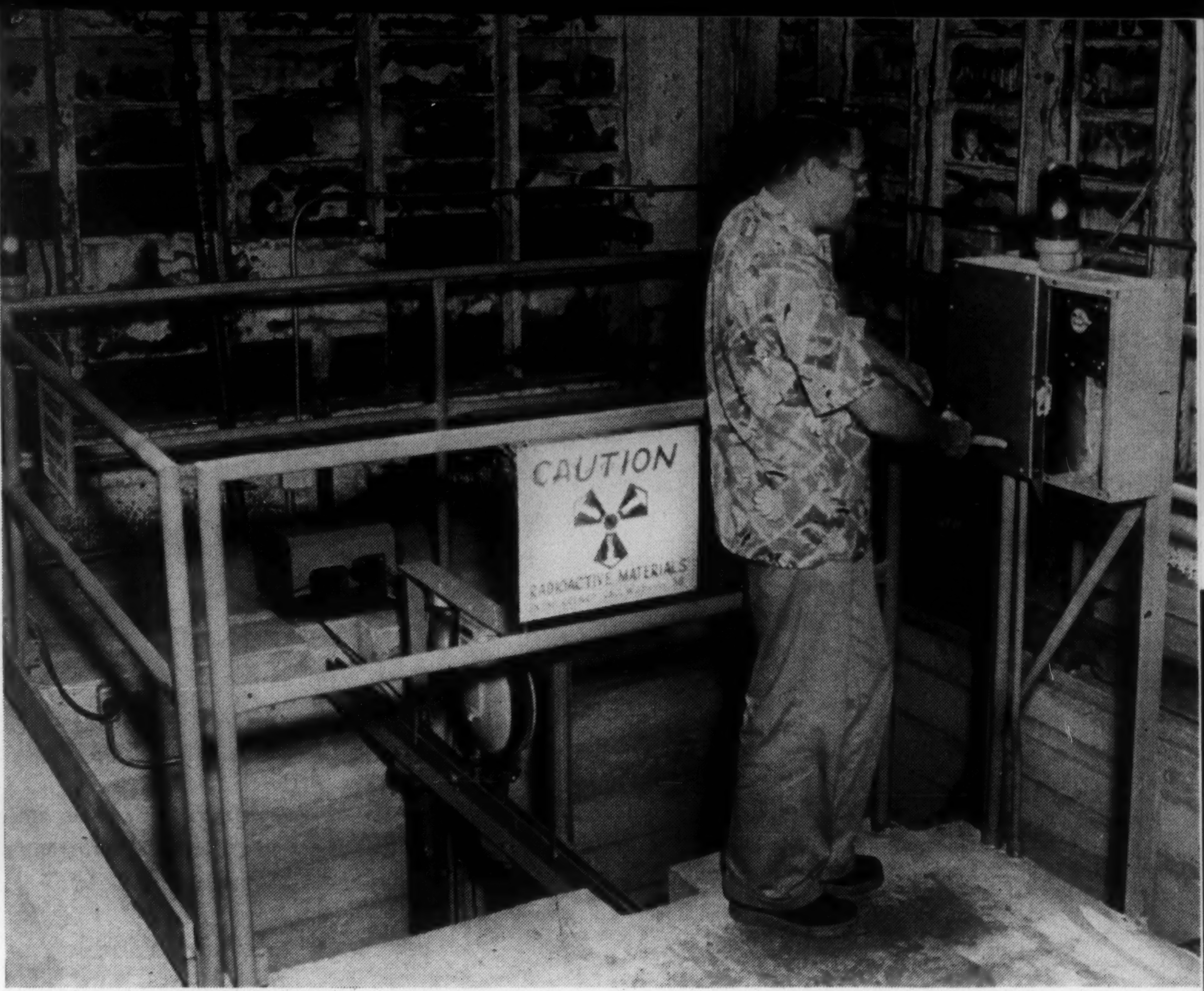


first upward motion of the cobalt 60 automatically switches on red lights atop the control panel and on the rail. The cobalt 60 continues its upward travel until the limit switch located on the cross member above the dome reaches the stop, near the top of the guide column. In this position the cobalt makes the top exposures on all four blades. The exposure time varies from 20 to 40 min depending upon blade size.

At the conclusion of the top exposure the timer and relay actuate the motor, which lowers the cobalt 60 until a bar on the cross member reaches the bottom limit switch, which is fastened to the guide column just above the top plate. In this position another exposure is made at the base of the four blades. This exposure time varies between 45 min and 1-¼ hr. When the bottom exposure is completed, the cobalt carrier descends until the lead dome rests flat on the top plate and the plug to which the cobalt 60 is attached continues into the lead safe. A final limit switch on the cross member turns off the motor and the red lights. Then the operator can descend into the pit to remove the exposed film. The blades can be safely removed and replaced with additional blades and the cycle repeated. A brake solenoid is also mounted on the cross member. Should current fail at any time during the cycle, the brake solenoid keeps the cobalt 60 source from dropping too rapidly and being damaged.

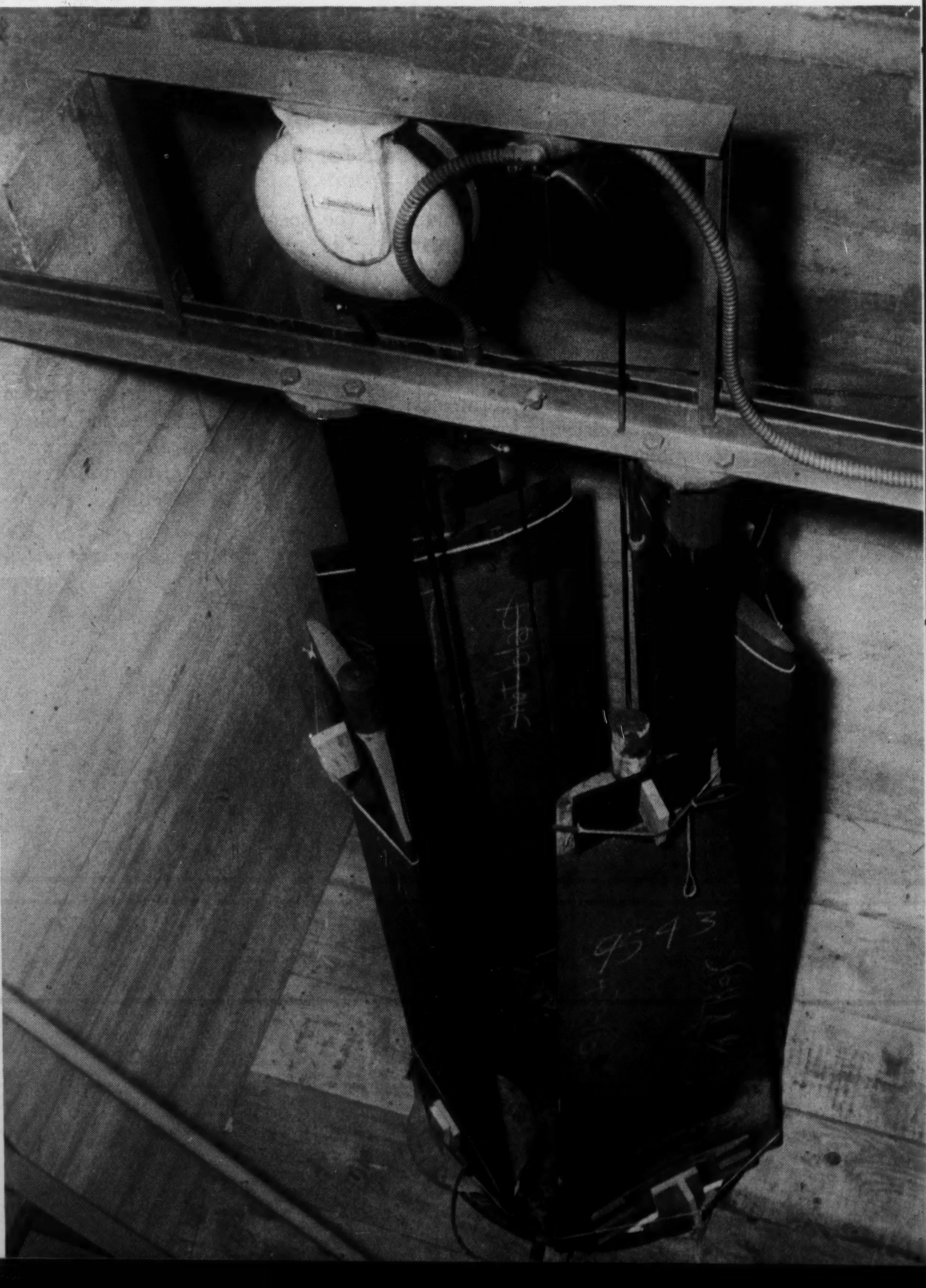
The radiographic pit was designed so that the radiographer and others working in the area receive no more radiation than 6-¼ mr per hr as required by the Atomic Energy Commission when using radioisotope sources. A radiation survey was made to confirm the safe operating level. The protection of shop personnel from the upward radiation is offered by the solid lead dome from which the source is suspended and the position of the radiation source below floor level.

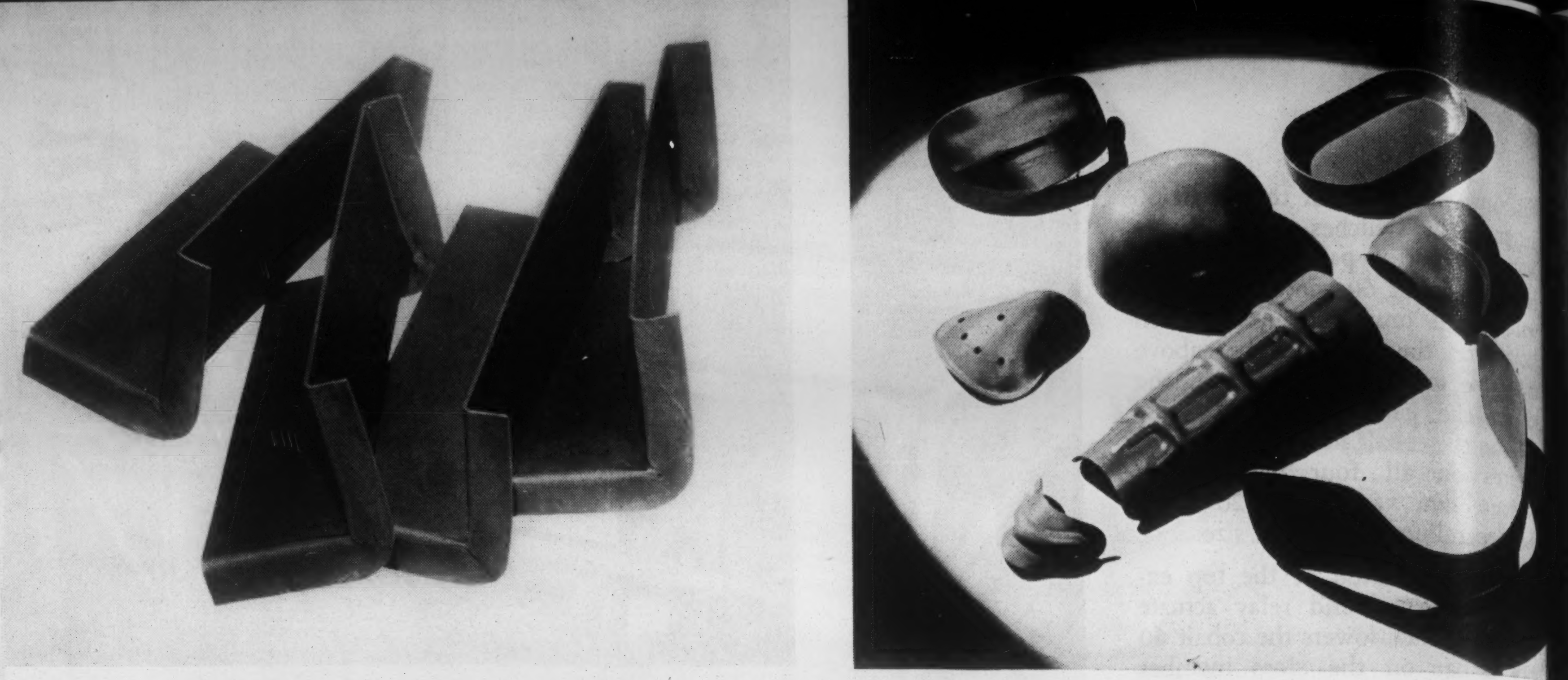
The use of this method has proven successful since production requirements have been met with a minimum of cost. In addition, the time required by the radiographer in making the exposure is a matter of a few minutes since it only involves locating and placing the film. After the radiographer actuates the motor, all exposures are made automatically, and he can perform other duties.



OPERATOR'S CONTROL *panel at floor level.*

RADIOGRAPHIC PIT *with film secured to top and bottom of four blades.*





These parts illustrate the excellent forming characteristics of vulcanized fibre. The athletic protective guards are shaped under pressures of about 200 psi. In the coil form parts, the fibre withstands high forming stresses without fracture as it is shaped into three mutually perpendicular surfaces.

Vulcanized Fibre: New Look at an Old Plastic

by GERARD A. ALBERT, Staff Manager of Manufacturing, National Vulcanized Fibre Co.

Here is a "refresher course" on a versatile engineering material that has been proving itself for 60 years.

● VULCANIZED FIBRE is a laminated plastic with only one component, cellulose. It is a tough, resilient, hornlike material weighing just about half as much as aluminum. It has excellent mechanical strength and good electrical insulating properties. In addition, it is easy to form, easy to machine and relatively low in cost. This combination of properties has found important applications for vulcanized fibre in many different industries.

Four grades of vulcanized fibres are recognized in NEMA specifications:

1. Commercial fibre—a mechanical and electrical grade for general-purpose applications.
2. Bone fibre—an exceptionally hard, dense grade used where close machining tolerances are specified or where unusual wear or abrasion will be encountered.
3. Electrical insulating grade—generally called "fish paper" and used for motor and generator insulation.
4. Trunk fibre—a tough, abrasion-resistant surfacing material for plywood.

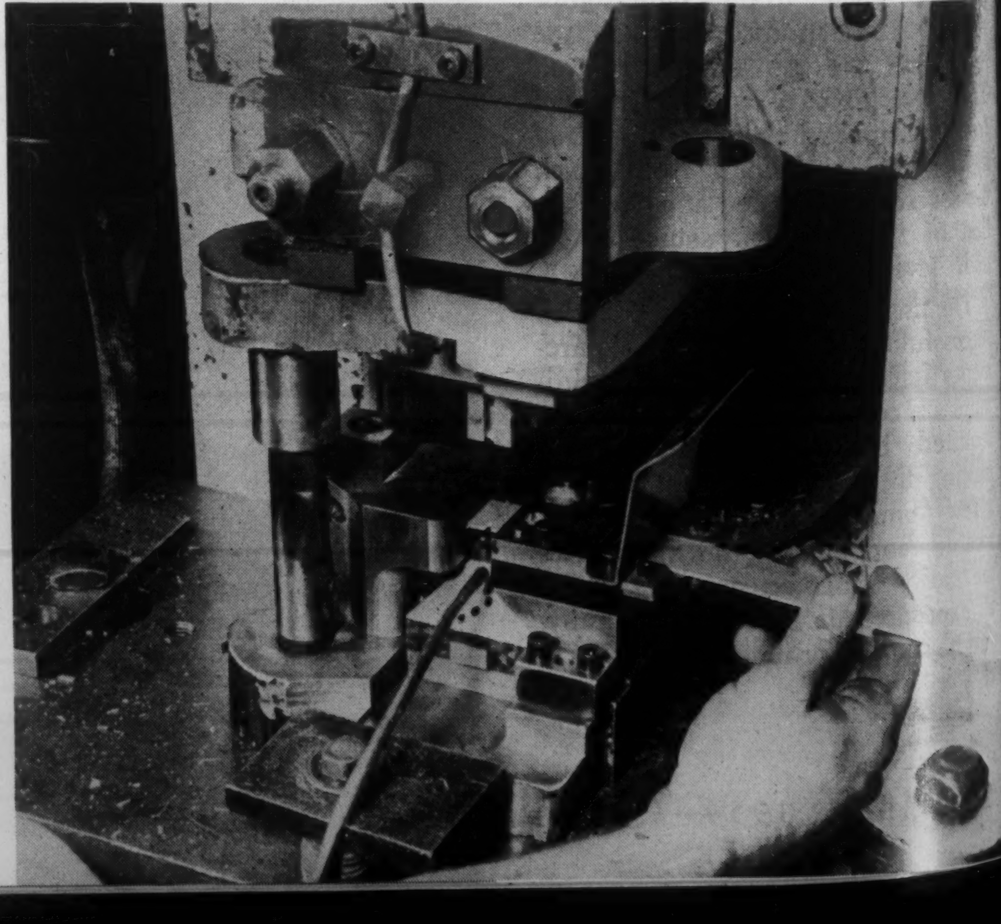
Many variations of these four basic grades have been developed to meet the special requirements of the textile, printing, abrasive disk, sporting goods, luggage and other industries.

Properties

As the data in the accompanying table indicate, vulcanized fibre is generally equivalent in performance to the phenolics. In certain respects, notably impact strength, vulcanized fibre is superior to most industria plastics. The principal advantages o the material are illustrated by th typical mechanical and electrical applications pictured and described elsewhere on these pages.

Moisture Absorption—Vulcanize fibre has a normal moisture conten of about 6% when it is in equilibrium with an atmosphere of abou 35% relative humidity. This moisture content changes with humidity at this level the change is on th order of 1% for each 7% chang in relative humidity measured a

Vulcanized fibre can be punched rapidly without cracking or chipping.



Properties of Vulcanized Fibre

Tensile Strength, psi	6000–12,000
Flexural Strength, psi	12,000–20,000
Compressive Strength, psi	20,000–30,000
Shear Strength, psi	11,000–15,000
Impact Strength, ft lb per in.	4–8
Rockwell Hardness	R60–R100
Modulus of Elasticity, psi	750,000
Density, gm per cc	1.0–1.5
Density, lb per cu in.	0.036–0.054
Dielectric Strength (short time ⅛-in.), v per mil	150–250
Power Factor, 1000 kc	0.03–0.08
Dielectric Constant 1000 kc	4–7
Water Absorption (2 hr -⅛-in. thk.),%	15–25
Thermal Conductivity, Btu/hr/sq ft/F/in.	3
Specific Heat, Btu/lb/F	0.37

77 F. The maximum moisture content, obtained from exposure to 100% humidity (water immersion), is 30%. Absorption drops off sharply at somewhat lower humidities. At 90% humidity, for example, moisture content is about 15%.

This tendency to "breathe" with the humidity affects the major properties of vulcanized fibre to varying degrees. Over a moisture content range of 4 to 32%, the density of vulcanized fibre drops about 0.3 lb per cu ft for each 1% of increase. Density change produces dimensional change. If vulcanized fibre is used in close-tolerance applications where atmospheric conditions vary widely, allowance must be made for dimensional changes.

Flexural strength, Rockwell hardness and dielectric strength are also affected by moisture absorption. These properties drop about 25% when humidity is raised from 35 to 60%. Where dielectric strength is needed in outdoor applications, as in power line fuses and lightning arresters, vulcanized fibre is sheathed in a phenolic casing for greater weather protection.

In certain applications, such as railroad track insulation, moisture absorption may actually be an advantage because of the accompanying improvement in impact strength. A rise in moisture content from 6 to 11% increases impact strength by 50%.

Vulcanized fibre is impervious to most non-aqueous liquids, including gasoline, oil and other petroleum products, as well as most organic solvents.

Electrical Properties—Three characteristics of vulcanized fibre make it a highly useful electrical insulating material: good arc resistance, ability to decompose to a neutral gas, and good mechanical strength. All three play an important part in arc extinction.

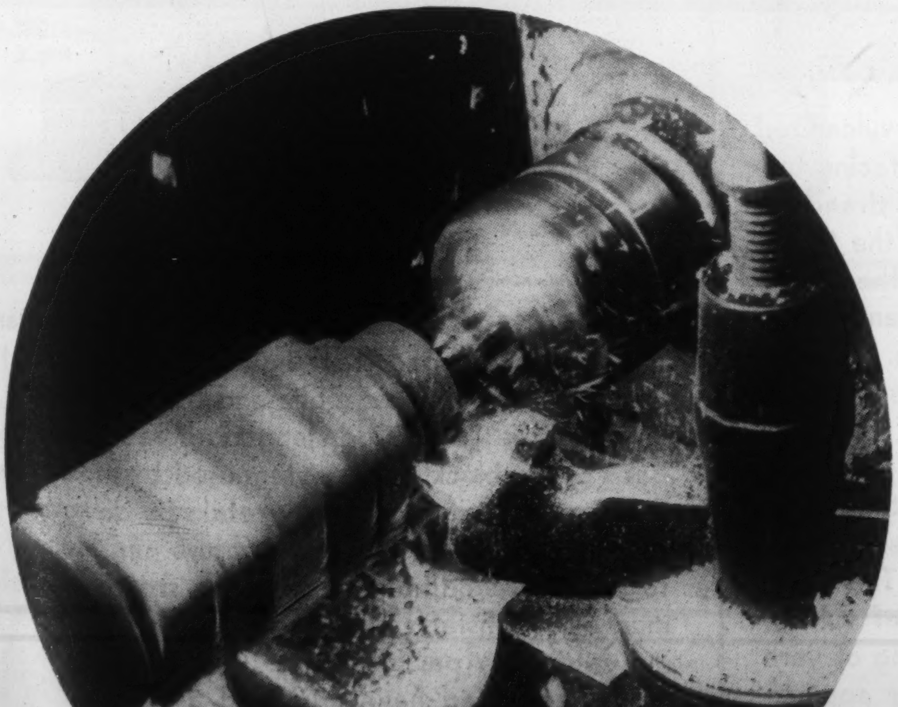
Vulcanized fibre is one of the most arc-resistant of available plastic insulating materials. Its failure to carbonize readily is explained by its cellulosic structure; it contains sufficient oxygen to combine in gaseous form with any carbon that might otherwise be deposited as a conducting solid. Some expulsion-type lightning arresters employing fibre tube can withstand surge currents of more than 100,000 amp without showing a trace of a carbon track.

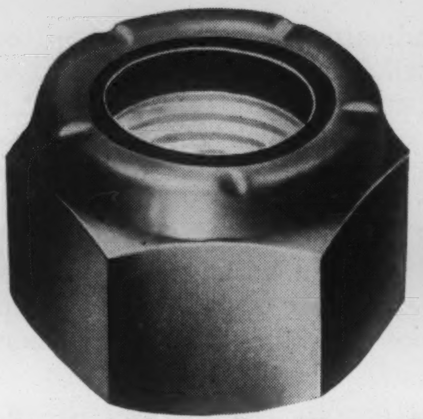
An important advantage of vulcanized fibre is its ability to produce large quantities of neutral gases under the heat of the arc. These

How Arc Extinction Works

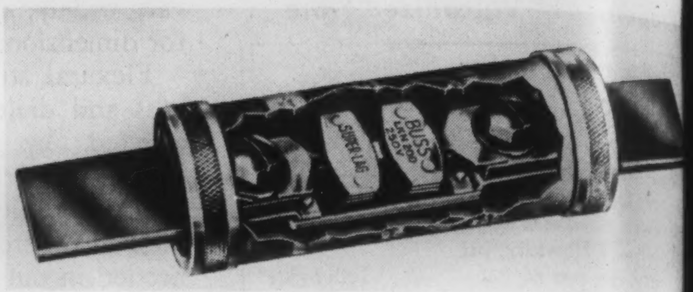
An air space supports an electrical arc because the air particles become ionized. Since the oppositely-charged particles tend to recombine into neutral particles, ionized air gradually loses its conductivity. The function of an arc-arresting device is to make this process occur as rapidly as possible. The usual method is to provide a solid surface of insulating material near the arc so that the charged ions can collect on the surface and be more readily available to oppositely-charged ions. However, some insulating materials are more effective than others. A material such as vulcanized fibre which decomposes into a neutral or uncharged gas under the heat of the arc is much more effective than a refractory material such as glass or porcelain. The gas inhibits arcing by preventing carbonization of the insulator. Gas evolution also produces a turbulence around the arc which causes the ionized air to mix more thoroughly and thereby accelerate the formation of uncharged particles. In addition, it creates sufficient internal pressure in the arresting device to blow out the ionized air stream. This is known as the "expulsion principle."

Lathe operations on vulcanized fibre are about the same as for brass, except that higher surface speeds can be used.

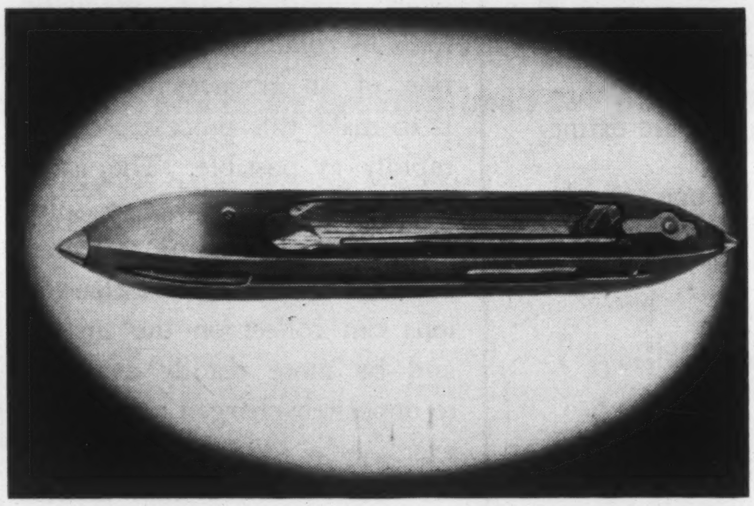




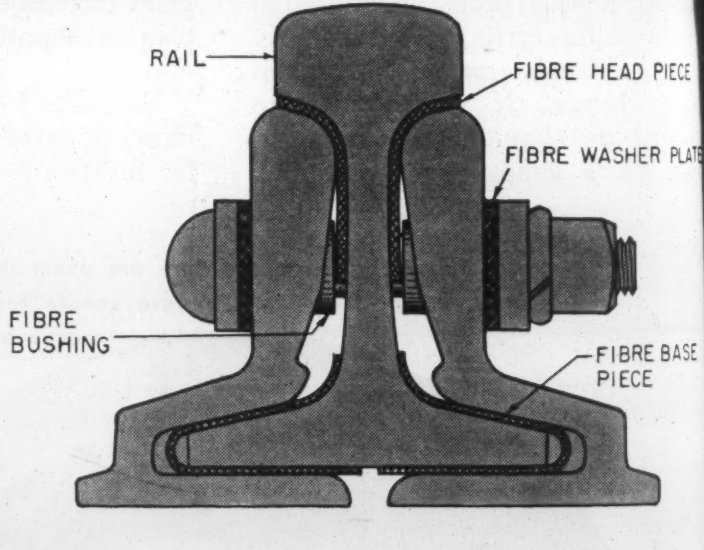
Self-Locking Nut Collar—The plastic collar in most self-locking nuts is vulcanized fibre. When a self-locking nut is screwed onto a bolt, the bolt cuts a set of mating threads on the inside wall of the slightly undersized fibre collar. The resilient fibre squeezes back against the bolt, thus preventing the nut from working loose under vibration. When the nut and bolt are disassembled, the natural elasticity of the fibre tends to restore the original shape of the collar, so the nut can be used many times without loss of gripping action. The resiliency of vulcanized fibre also makes it a good gasket material. Small amounts of plasticizer, added during fabrication, increase its pliability somewhat and improve its airtight sealing ability.



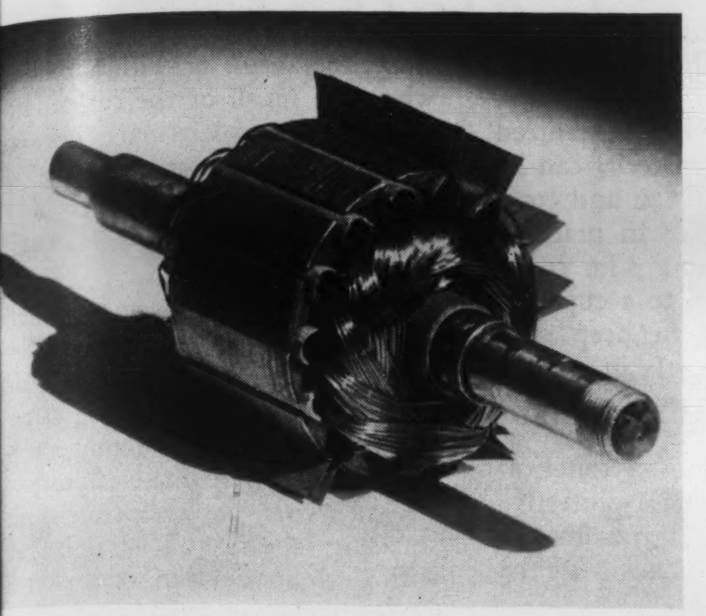
Fuse Housing—Because of its excellent arc resi tance, vulcanized fibre is often used as the housin for a cartridge fuse. As the cutaway shows, a fib tube is fitted with metal ferrules that hold the fus assembly inside the tube. Fuses intended for outdoo use utilize a "combination tube" consisting of a vu canized fibre tube with a protective phenolic sheat A combination tube is also used to house the interrup ing switch employed in high voltage circuits. In orde to avoid arcing across the contacts when the breake arm operates, the switch is designed so that any a produced is immediately drawn to the inside of th tube where it is dissipated by the neutral gas evolve by the vulcanized fibre.



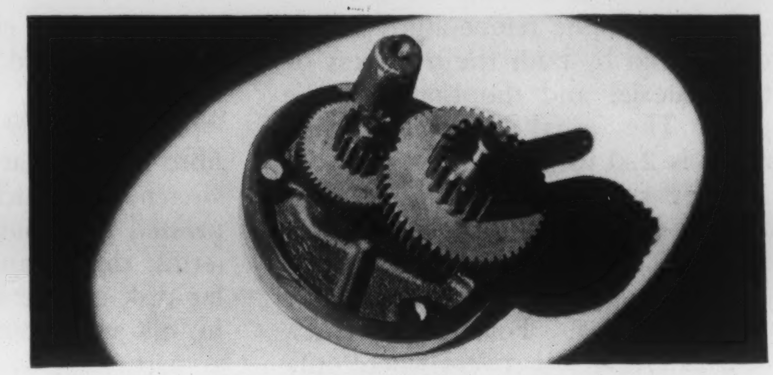
Textile Shuttle—A special grade of vulcanized fibre, known as "shuttle fibre", is used as a facing material on the wooden shuttle that carries the strands of yarn back and forth across the loom during the textile weaving process. At each end of the loom the shuttle is struck by a pivoted lever or "picker stick" and accelerated from a dead stop to nearly 3000 fpm. The surfacing material must withstand the repeated impact without splintering, and it must remain perfectly smooth so it does not snag the yarn as it plays out. Vulcanized fibre offers not only the required toughness, but also the tendency for a smooth, machined surface to become more highly polished with use. This same retention of smoothness has led to the use of vulcanized fibre in bobbin heads where rapid feeding of yarn without snagging is also important. Another application where impact resistance is significant is the bumping block in a pneumatic tube system. Although the loaded carriers weigh several pounds and travel at nearly 20 mph, a vulcanized fibre bumping block survives repeated impacts for years without replacement.



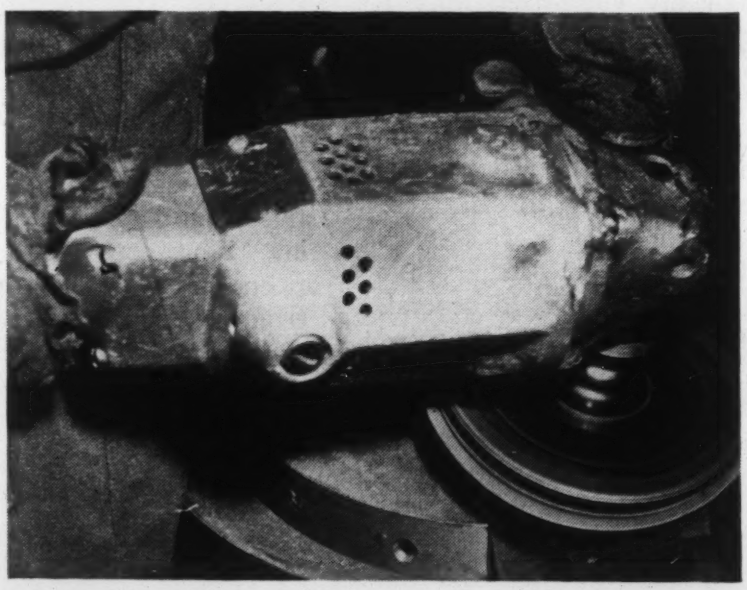
Track Insulation—Vulcanized fibre is a standard material for railroad track insulation. This insulation is required for tie plates, bolts and butting rails at joints between the "blocks" or lengths of rail which are the basis of the block signal system used by most railroads. This insulation must not only retain its dielectric properties at all extremes of temperature and humidity due to weather conditions, but, as the sketch indicates, it must also withstand repeated pressure and shock loading caused by passing trains. All other materials that have been tried have crumbled away, usually within one or two years and often in a matter of months. In contrast, of 6000 vulcanized fibre shims installed on a section of track near Pittsburgh subjected to particularly heavy freight traffic, only 60 (just 1%) had to be replaced after 7½ years of service.



rmature Insulation—Good dielectric strength, nsile strength, flexibility and resiliency make slate- ay "fish paper" an ideal insulating paper for arma- re slot cells. This grade of vulcanized fibre is widely ed to insulate coils and windings in motors and enerators.



Ironer Gear—Steel and vulcanized fibre gears are used together in this exceptionally quiet-running gear train from a household ironer. The toughness and resilience of fibre gears give them the ability to resist severe starting torques. The fibre gears not only have long wear life but also promote longer life for the metal gears than they would have in an all-metal assembly. A fibre gear is designed with a face width about twice that of a metal gear subjected to equivalent working stresses. The bone fibre grade is usually selected for this type of application because of its superior machinability.



Abrasive Disk Backing—Most abrasive disks used for grinding and polishing have a thin backing of vulcanized fibre. A disk should spring back into shape even after high-speed grinding on curved surfaces and corners where contact pressure is concentrated in one area of the disk. Vulcanized fibre provides the required combination of resilience and tear resistance. The disk is made by coating the fibre (usually 0.030 in. thick) with a resin binder and depositing the abrasive grains on the resin. A heavy-duty disk has an intermediate cloth layer between the fibre and the abrasive.

ases consist of about 50% carbon onoxide and 45% hydrogen, with he remainder a mixture of hydro- arbon gases and water vapor. Many rc-arresting devices are designed pecifically to take advantage of this haracteristic.

Gas evolution inside a tube cre- tes large instantaneous pressures. he insulating material must resist he tendency of the suddenly-applied tresses to rupture the tube wall and trip the threads that hold the metal nd plugs. Here, the impact strength r shock resistance of vulcanized ibre—three to seven times greater than that of other organic insulating materials—is of particular advantage. In addition, vulcanized fibre does not soften nor lose any of its mechanical strength when exposed to the high temperature of an electric arc.

Formability

Relatively thin sections of vulcanized fibre can be readily curved, bent and deep-drawn without sacrificing strength in any area. Generally, the first step in forming vulcanized fibre sheet or tubing is softening it by immersion in hot water (160-210 F) or in a live steam chamber. Immersion time required depends on thickness of the material and shape of the part to be formed. Simple shapes can be formed after merely wiping the material with a wet cloth or dipping it in water. For thicker or more complex shapes, it may be necessary to soak the fibre 30 min. or longer.

When the fibre is sufficiently plasticized, it is placed in a heated metal forming die and held there for a period ranging from a few seconds to a few minutes to "set" the new shape. Die temperature also is determined by both the thickness of the material and the shape of the part. The usual die temperature range is 220 to 300 F.

Many simple shapes, such as the athletic protective guards pictured in this article, can be formed with pressures of about 200 psi based on projected area. For larger parts, such as cylindrical covers where only the periphery of the piece is to be formed, the force required is usually calculated on the basis of the linear dimension or circumference. This calculated force rarely exceeds 700 lb per linear in.

How Vulcanized Fibre is Made

Making vulcanized fibre is a relatively simple process. Paper is made from cotton fibres obtained by digesting clean cotton rags. Various types of paper are made, depending on the grade of fibre desired. The cellulose paper is passed through a zinc chloride bath which changes the fibre structure and puts the paper in a semi-gelatinous condition. The paper is then plied up to form sheets of desired thickness or wound upon mandrels to form tubes of desired diameter. The zinc chloride is removed by leaching; thus the final material is chemically-pure converted cotton cellulose. The sheet is dried under heat and pressed. Rods are made by grinding down bars cut from sheet stock.

One of several producers, National Vulcanized Fibre Co. makes vulcanized fibre in strips and 48 x 80-in. sheets ranging from 0.004 to 2 in. thick; in tubes with outside diameters of up to several inches and wall thicknesses from 0.020 to ½ in., depending on inside diameter; and in rods with diameters from ⅛ to 2 in. The material is available in virtually any color from pure white to black, including all primary colors, but gray, black and red are the most commonly used.

The plasticity of wet vulcanized fibre is such that the material can be stretched as much as 25% and compressed by about 50%. In practical terms, this means that a 3-in. circular disk can be drawn to a cup 1½ in. dia and about 1⅛ in. deep. For a part roughly cubical in shape, depth of draw should be about one-third the length of the diagonal of one face. The depth of a spherical draw, as in the crown of a protective helmet, should be approximately one-half the average diameter of the opening.

Although fibre of all thicknesses can be formed, considerable attention must be given to radii of bends and to depth of draw in the thicker materials. For parts such as helmets that have sharp curvatures, the material should be 1/16 to 3/32 in. thick to permit a good draw and, at the same time, provide the necessary strength and rigidity in the finished part.

Although dry vulcanized fibre is essentially a thermoset material below 250 F, it becomes moderately thermoplastic if heated to about 350 F. At this temperature it can be post-formed into relatively simple shapes, but the extent of draw or bend obtainable with heat alone is considerably less than that possible when the fibre is wetter. In general, vulcanized fibre and the laminated phenolics have similar post-forming properties. The heating interval for post-forming should be quite short; a period of 15 sec. is enough for a 1/16 in. thick piece of fibre placed between two 400 F platens. The piece forms quickly when the die is closed, but it must cool to 250 F before removal in order to retain its formed shape. Since little distortion occurs in the hot-forming of simple shapes, a fibre blank can be otherwise completely fabricated prior to forming.

Dry vulcanized fibre can also be swaged by forcing it into die cavities under high pressure, usually with some heat. The combination of high pressure and the plasticizing effect of the heat enables the fibre to flow and fill the cavity.

Machinability

Vulcanized fibre can be sawed, drilled, milled, punched and otherwise machined as easily as brass or wood. It can be cut with a circular saw to provide smooth edges and close tolerances, or with a band saw when the finish of the cut surface is not critical. Circular saw cuts should be made at 2700 to 3200 rpm; band saw speeds should be between 4000 and 5000 linear ft per min.

Vulcanized fibre can be milled with high-speed tungsten carbide or Carboloy-tipped tools. Machine speed should be about the same as for brass, i. e., approximately 400 ft per min. The material may also be cut with power-operated metal squaring shears. A straight knife will give good clean edges on material up to ⅛ in. thick.

For drilling, a high-speed Bakelite drill is recommended. The drill should not be forced, especially when working parallel to the laminations. It is advisable to back drill out frequently for cooling and to clean away chips.

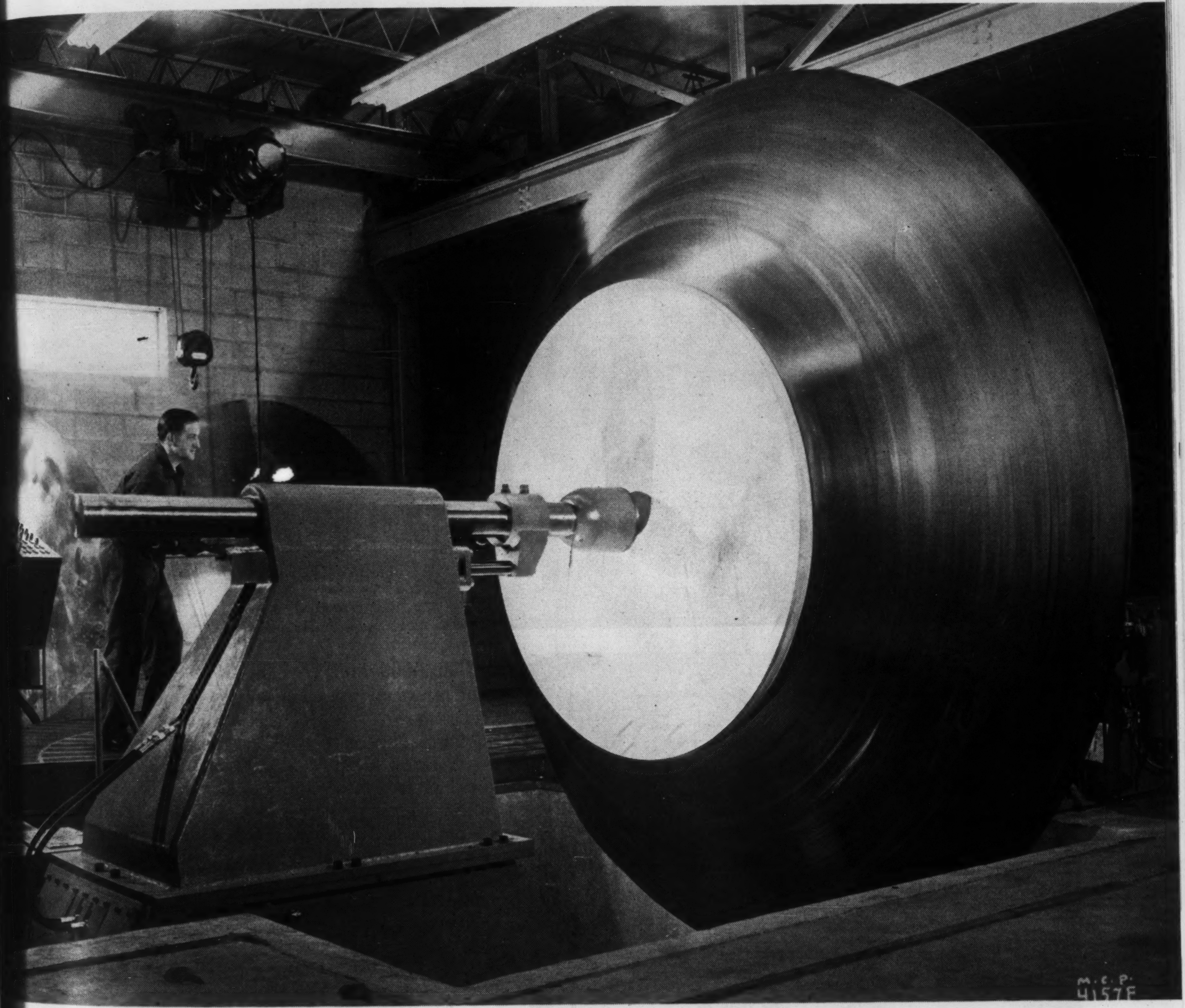
Vulcanized fibre can be tapped with standard metal taps. However, the ream should be 0.003 to 0.006 in. larger than the final diameter desired because of the spring-back tendency of the fibre. Recommended tapping speed is 100 ft. per min. When holes are being tapped parallel to the laminations, the material should be clamped to equalize stresses and prevent possible splitting. Fibre may also be threaded on an engine lathe, and this method is recommended for fine threads. Rotation speed is the same as for brass, approximately 70 rpm.

The material can be punched easily. Compound dies are recommended for intricate pieces and progressive dies for high-speed fabrication. Punches must be made oversize for hot punching since the fibre shrinks during cooling. The amount of oversize needed depends on material thickness, temperature and size of the punch. For a ⅛-in. hole in 1/16-in. stock, the punch should be 0.003 to 0.005 in. oversize. For a ⅛-in. hole in ⅛-in. stock, the punch should be 0.012 to 0.015 in. oversize. Cold punching produces good edges on ¼-in. stock but thicker stock should be heated to about 180 F.

Shaving will produce smooth edges if the edge of the die is beveled at about 45 deg for a distance of 1½ to 2 times the thickness of the stock. Fibre up to 1½ in. thick can be shaved cold, but thicker sections should be heated before shaving.

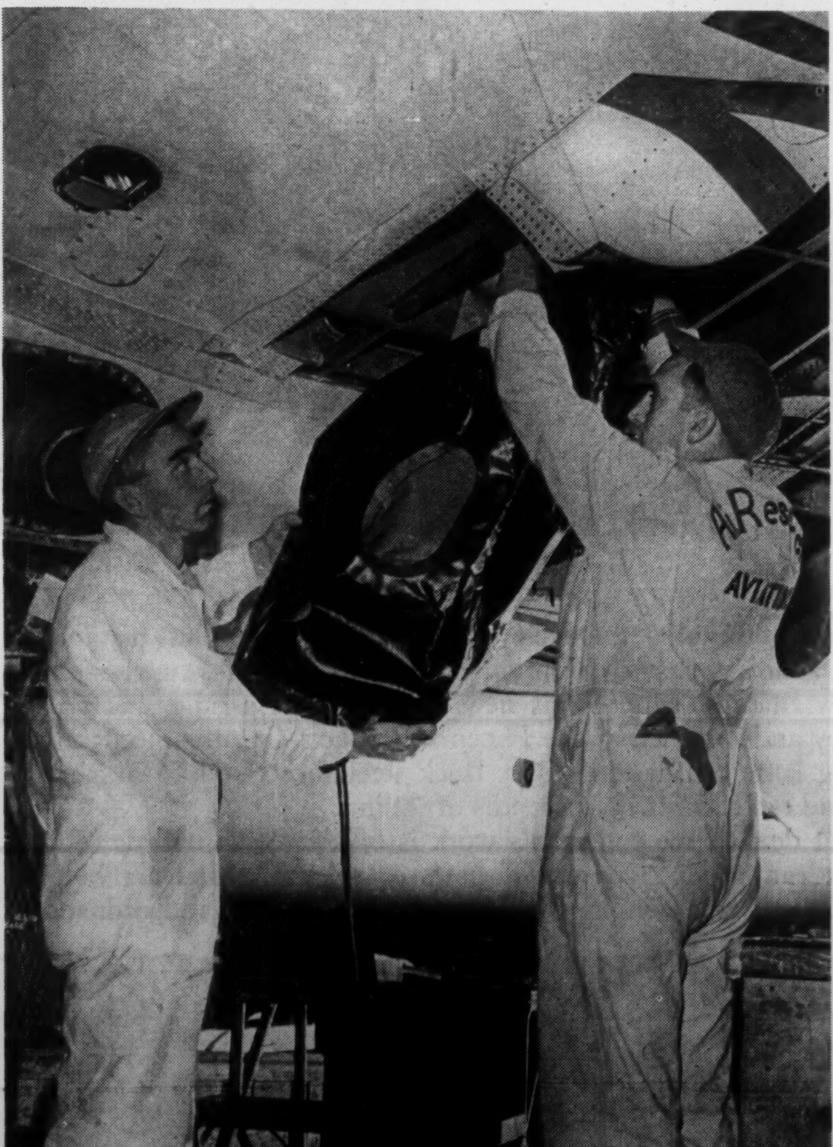
Materials at Work

Here is materials engineering in action . . .
New materials in their intended uses . . .
Older, basic materials in new applications . . .



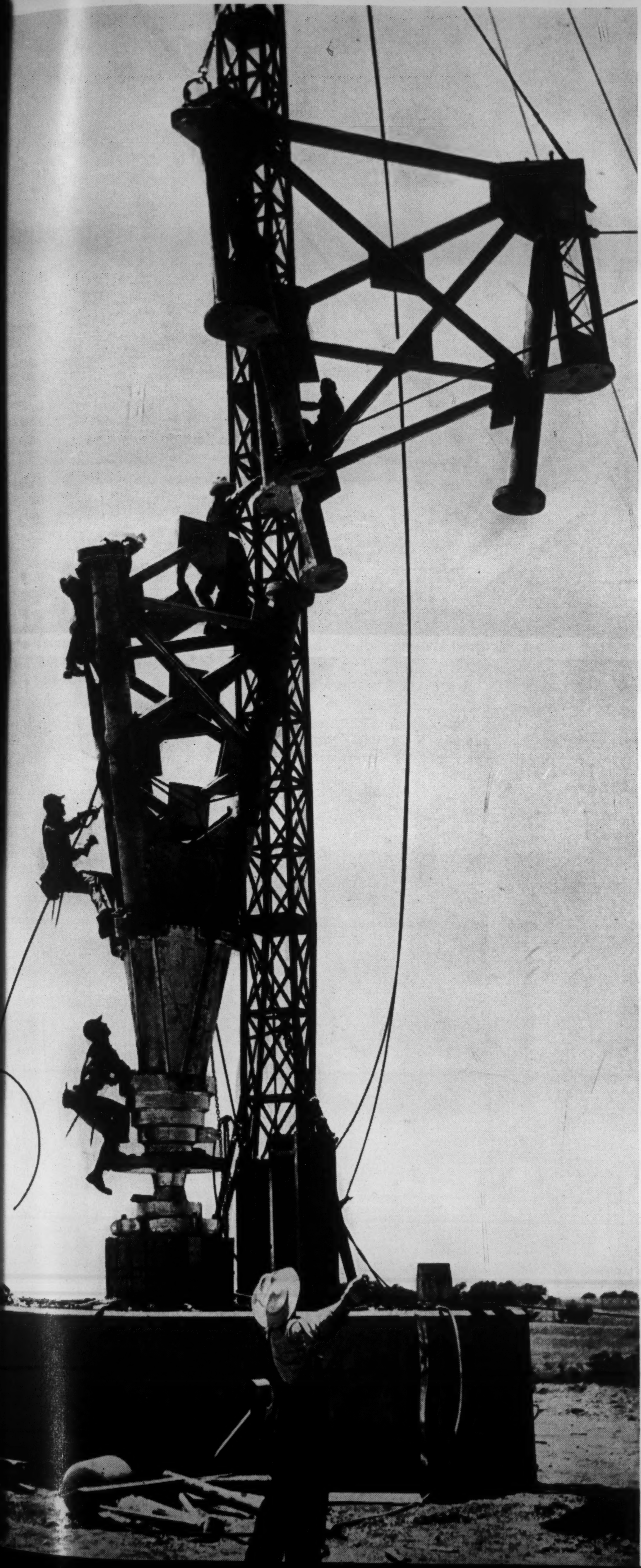
Spinning Jumbo Sheet Metal Developed for the spinning of materials such as aluminum stainless steels, chromium-molybdenum steels, cupro-nickel alloys and the new titanium alloys, this new machine will handle sheets up to 180 in. Built by and installed at the Phoenix Products Co., the electrically controlled spinning lathe can handle 3/8-in. thick steel sheets and 3/4-in. thick aluminum sheets and can form them to depths of 72 in.

Although a great deal of the company's work is of a research and development nature, short run production lots of parts or sub-assemblies are being produced for items such as jet engines, guided missiles, aircraft and ordnance components.



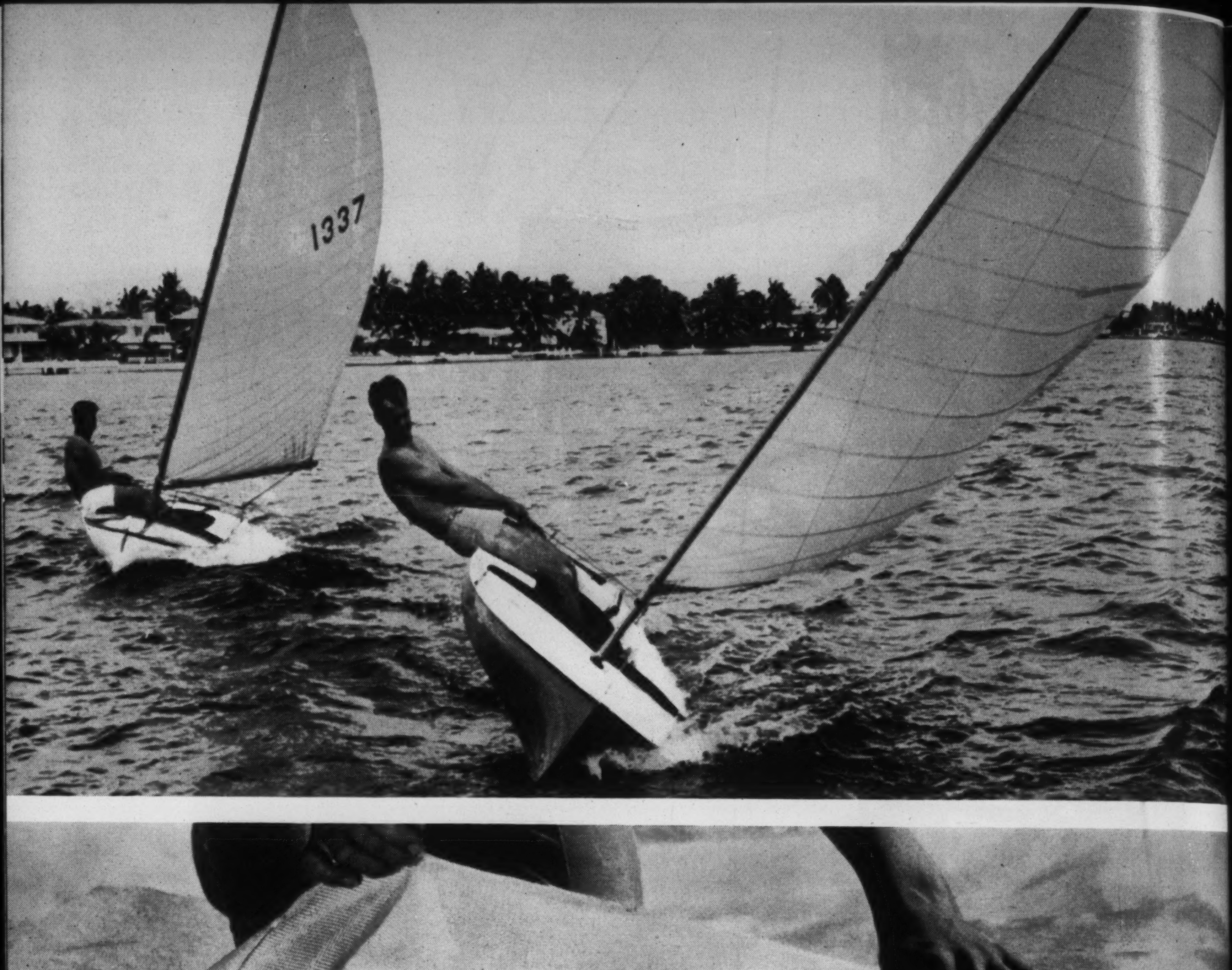
Nylon Adds Life To Fuel Cells Safety, economy and greater range are features claimed for nylon fuel cells shown here being installed in a Lockheed Lodestar. The cells, made of nylon fabric and coated with nylon film, are said to eliminate gas leakage, to be less likely to rupture during a belly landing, to allow a greater fuel capacity, and to be easily repaired.

Engineered by AIResearch Mfg. Co., a div. of the Garrett Corp., and fabricated by the Goodyear Tire and Rubber Co., the fuel cells have received CAA approval, and only slight structural alterations are necessary for installation.



Welded Steel Tower, Highest In the World? Welded steel sections are shown being bolted together to form the tapered base for a new TV antenna tower which will reach 1572 ft from the ground (Empire State Building is around 1300 ft). Under construction in Oklahoma, the total structure will weigh over 675 tons and will be anchored by galvanized, pre-stressed bridge strand guying cables with a total length of over 5 miles.

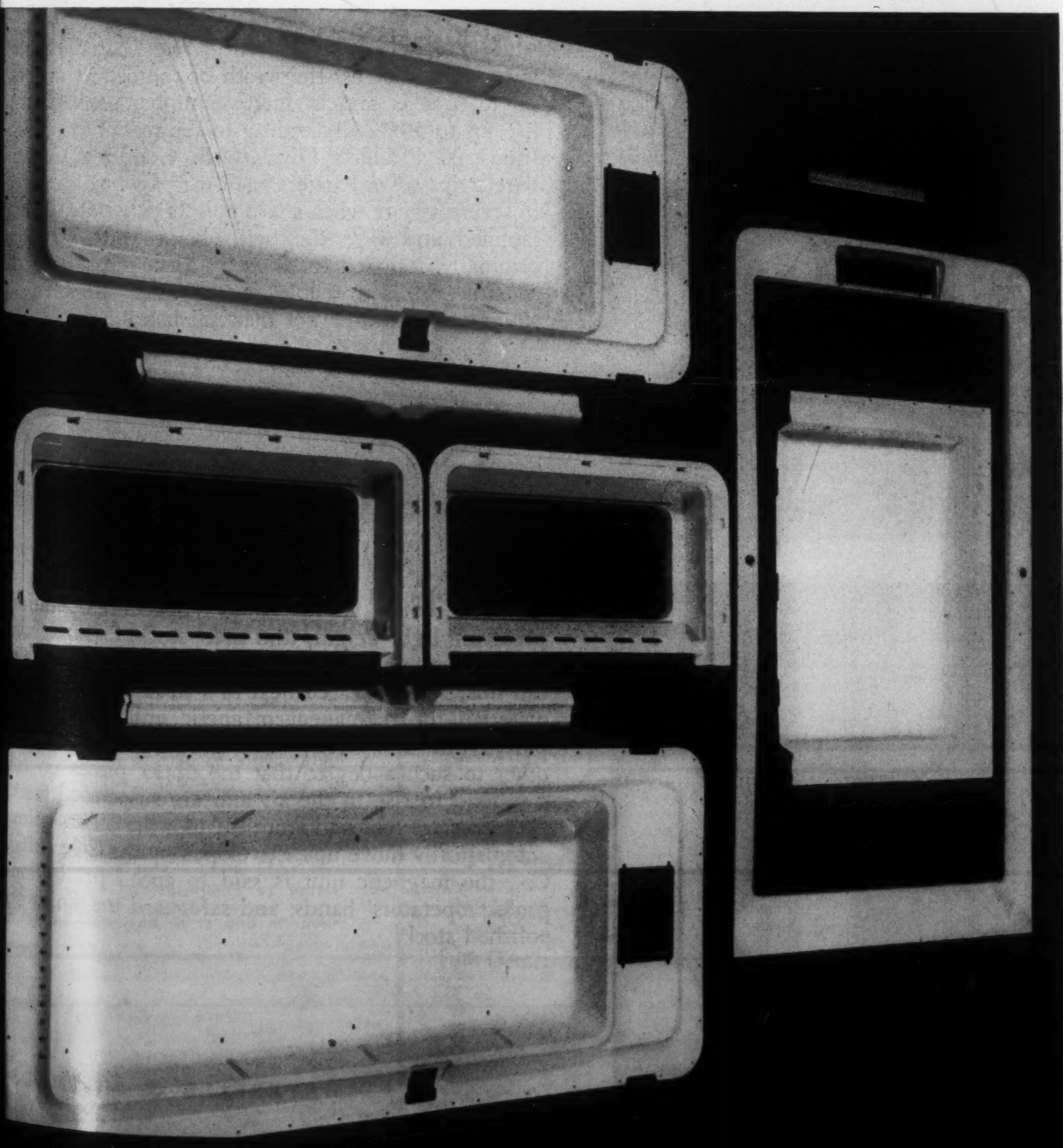
The construction and design, developed by the Ideco Div., Dresser-Stacey Co., incorporates around 11,000 lb of the Lincoln Electric Co.'s Jetweld electrodes.

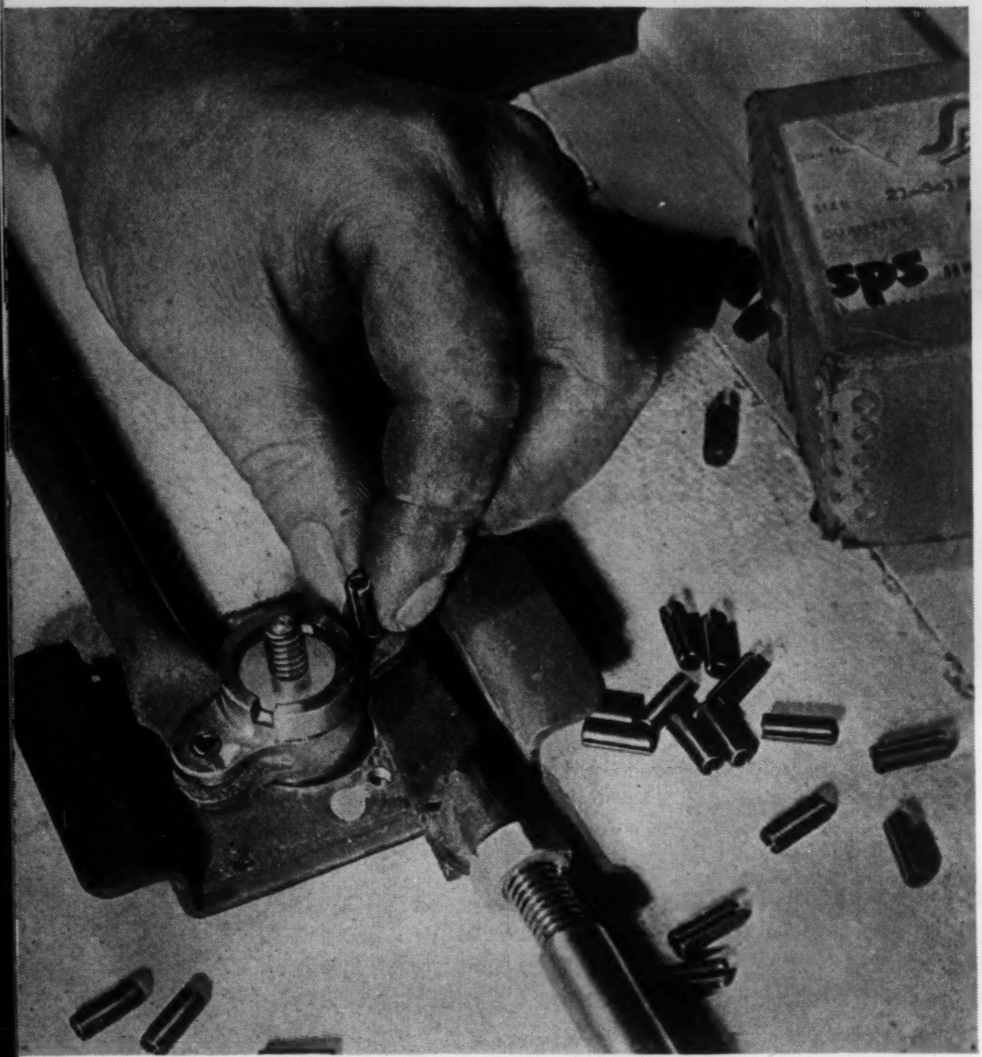


Paper and Plastics Afloat Kraft paper and phenolic plastic, combined in a honeycomb structure (bottom), provide a light-weight, buoyant deck for the Moth Class sailboat shown at top. The kraft honeycomb core is impregnated with Bakelite phenolic resins, and the whole is faced with a glass fiber-reinforced plastic cover, providing a smooth, hard interior and exterior surface. The honeycomb structure is also used in such applications as aircraft sections, building panels and school desk tops.

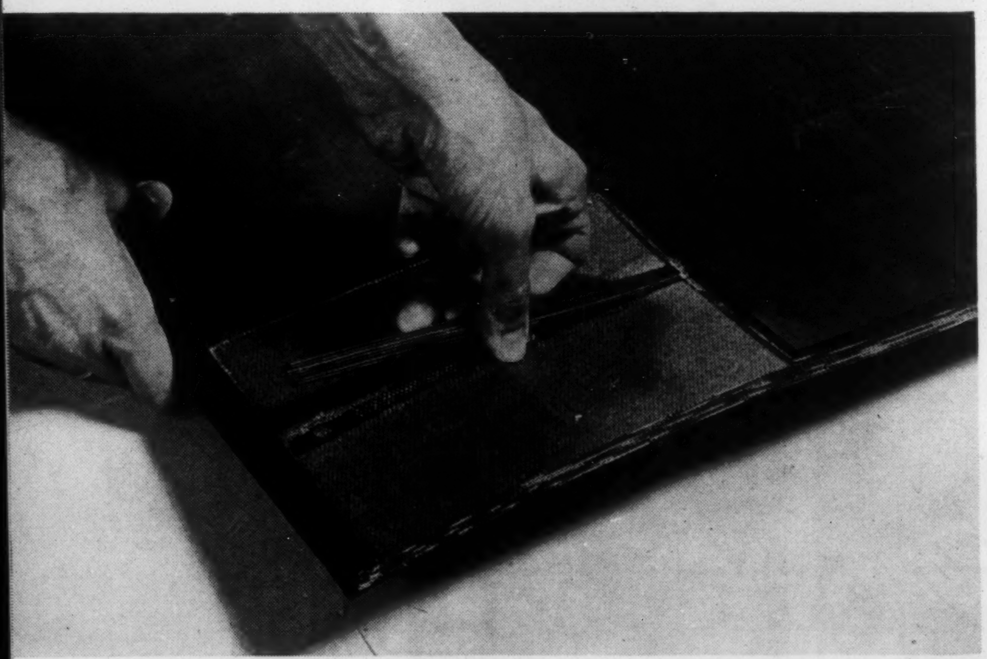
ilicone Rubber Adds Grease Resistance
o Fabrics Shown after being rolled once
ith the standard 4-1/2-lb steel roller, the
lass cloth sheet at left coated with the new
licone rubber compound shows no crease,
hile the one at right, coated with similar
pe of material, takes on the beginning of
permanent crease. The material, developed
y Dow Corning Corp., is an improved ver-
on of Silastic 132, retaining the same ten-
ile strength and said to provide higher
ease resistance and high dielectric strength.

lastics Looms Large In Refrigeration Use In the last 10 years the use of plastics materials has
rown from a negligible amount to around 25 lb. Shown here are typical parts made of new high-
npact styrene, which is said to make up about 65% of the plastics used. Fabricated of Monsanto Chemi-
al Co.'s Hi-Test 88 Lustrex, the parts shown are a one-piece breaker frame and one half of an inner
oor panel at top, and door liners, freezer compartment liners and breaker strips at bottom.



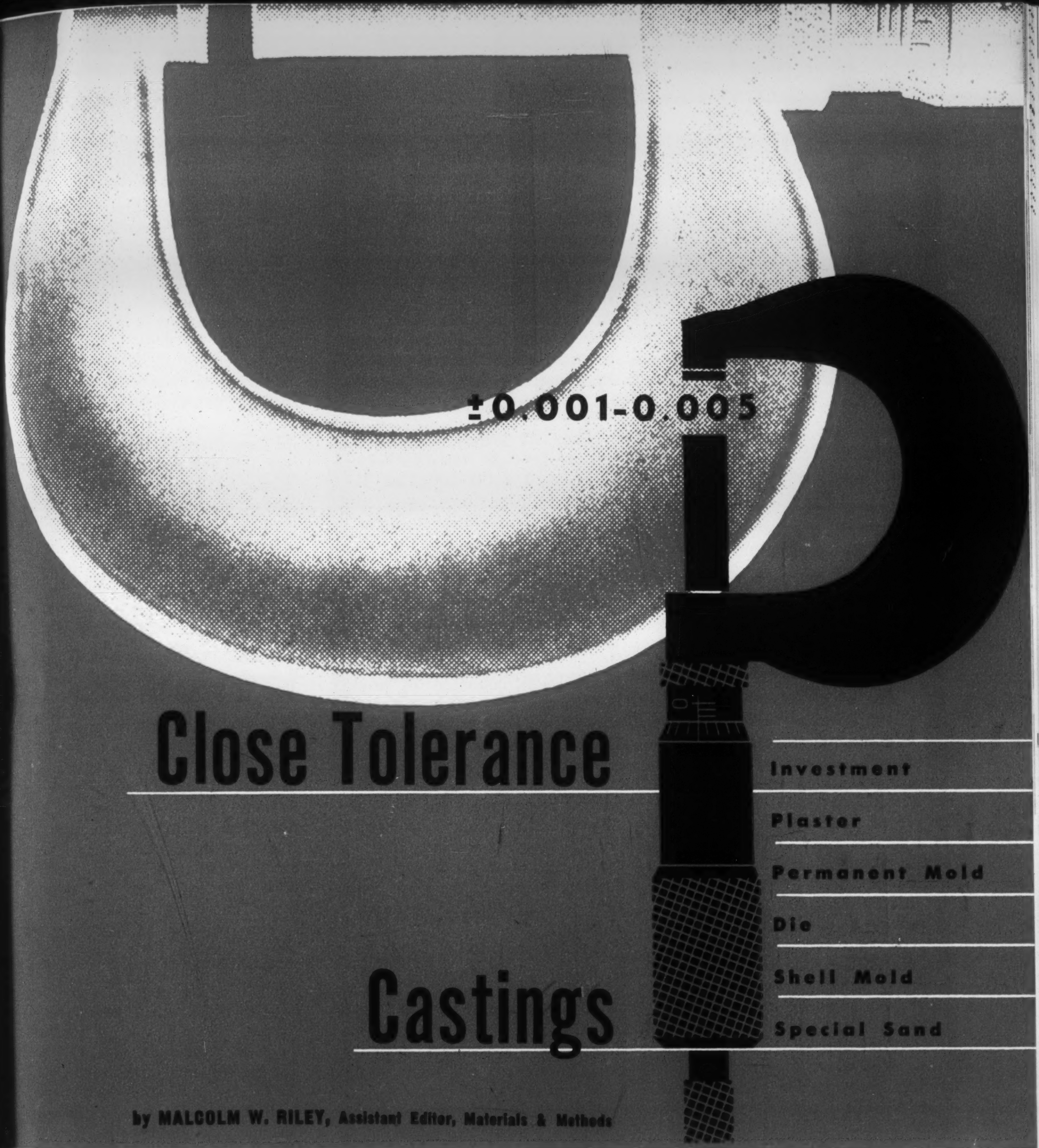


Joining Gimmick Shown being installed in the holes of the bell crank used in the latch mechanism of berths for B&O sleeping cars, Sel-Lock spring pins allow simple installation, and act as axles for the mechanism. The pins are forced into holes slightly smaller than their own diameter, and the spring action of the pins hold them in place. Manufactured by Standard Pressed Steel, the pins replaced rivets in this application with a resulting savings in fabrication time.



Steel Protects Rubber Belt High strength steel wire inserted across the width of the belt at intervals up to 3 ft is said to increase rubber conveyor belt life up to 50%. According to the manufacturer, the Industrial Products Div., B. F. Goodrich Co., the wire strips act as barriers against rips which can occur in severe service when sharp objects penetrate, become jammed and slice the belt like a knife. Though originally designed for foundry shake-out service, the construction is available for a variety of uses, including all types of hot material handling.

Magnet "Fans" Metal Sheet Speeding operations involving light-weight, thin sheet stock, this magnetic "fanner" safely separates metal blanks, tin plate and can lids. When placed next to a stack of this type of material, the permanent magnetic unit induces like polarity in the sheets, causing them to repel each other to such a degree that the upper pieces on the pile tend to rise in the air and are suspended there. As pieces are removed from the top, the others below automatically move up. Developed by the Eriez Mfg. Co., the magnetic unit is said to speed production, protect operators' hands, and safeguard the finish on polished stock.



Close Tolerance Castings

- Investment
- Plaster
- Permanent Mold
- Die
- Shell Mold
- Special Sand

by **MALCOLM W. RILEY**, Assistant Editor, Materials & Methods

MATERIALS & METHODS

Manual No. 108

This is another in a series of comprehensive articles on engineering materials and their processing. Each is complete in itself. These special sections provide the reader with useful data on characteristics of materials or fabricated parts and on their processing and applications.

SEPTEMBER 1954

Casting metals to close dimensional tolerances can substantially reduce the end cost of a product. This manual indicates the advantages and limitations of each of the six basic types of close tolerance castings in order to aid in the selection of a metal forming method. Discussed in each section are:

- ***Materials***
- ***Methods***
- ***Design Factors***

Introduction

Precision and generality are two words which do not normally fit together. You might ask then how a subject dealing with a relatively high degree of precision can be covered in a general way. Is it true that the features and limitations of each method of casting to close tolerances are directly dependent on the design of each part and therefore rules cannot be laid down which will hold true for all the processes. There are, however, certain characteristics of each process which make it more suitable for casting certain types of parts. And though there may be many areas where they overlap and are highly competitive, each of them definitely fills a certain need in the metal forming field. It is the purpose of this manual to delineate these areas as clearly as possible in order to narrow the field of selection for the engineer.

Six basic processes are covered here: 1) investment casting, 2) plaster mold, 3) permanent mold, 4) die casting, 5) shell molding and 6) some specialized sand casting techniques. Unfortunately space does not permit describing some of the specialized casting techniques which combine several advantages of these six, e.g., sand and plaster, sand with various types of binders. But these six basic processes allow a wide range of materials, shapes, sizes and characteristics for commercial production of close tolerance castings.

In each section covering a specific kind of close tolerance casting, the process is described briefly and the limitations and advantages discussed. Some foundries have had occasion to work to closer tolerances than others. In these cases, examples are given and extreme cases mentioned. A case history with each process illustrates the type of part which particularly lends itself to that casting method.

Why A Casting

There are several reasons for investigating close tolerance casting, and they all boil down to cost. There are some parts with areas which could not be machined if formed in one piece. Such parts must usually be made in several pieces, machined and assembled. By using a suitable casting method, it may well be that the part could be cast in one piece, maintaining the surface finish and dimensional accuracy in critical areas in the as-cast condition. By producing the part as a casting, machining and assembly costs can be reduced. In addition, duplicate fabricating and assembly equipment can be eliminated. Where a part is presently being formed in one piece but heavy machining and finishing is necessary to produce required accuracy, close tolerance casting may substantially reduce machining to the point where only a minor finishing operation is necessary.

Another point to be considered is the higher material yield obtained when machining is reduced. This can be a determining factor when coupled with the reduction in machining time. In general, more machining means more scrap and a higher materials cost per part.

It should be realized that casting metals to dimensional tolerances of ±0.001 to 0.005 in. is highly specialized work requiring close control over all the variables encountered in foundry work, such as pattern making, mold or die making, composition of the alloys, cleanliness of the alloys, melting techniques, etc. This generally will raise the cost of the casting process itself. The comparison, then, between parts made with one of these processes and another method should be made on the basis of the end cost of the finished part. If the cost of the casting represents an increase in the primary cost of the part, it may well be over-balanced by the reduction in supplementary operations. This can result in a substantial reduction in the over-all cost of the finished part.

It is easy to oversell close tolerance casting processes. They are capable of some extraordinary results, particularly when working in the laboratory or in pilot quantities. The engineer who is selecting a method of producing a part is not interested in what can be done under the controlled conditions of the laboratory. He wants to know what can be done on the pouring floor, under commercial production conditions. None of these processes is a panacea. There are very few cases where close tolerance casting will eliminate all seconday machining operations if extremely high accuracy is required. In most cases machining will be reduced to a point where it is merely a finishing operation, but no casting process can replace machining to attain greatest accuracy. It is all a matter of degree.

How To Select The Casting

In the final analysis, no one can lay down definite rules to follow in selecting one of the six major types of close tolerance casting. Some are so new that their limitations have not been fully explored, and the foundrymen themselves do not know exactly what parts can be produced until they look over the specifications. There are, however, certain factors peculiar to each process which definitely limit it to the production of certain types of castings. After this first step of eliminating those methods which cannot be considered, the only way to determine the most economical one is to consult the engineer in the foundry. He can determine whether the part lends itself to that process, and can aid in designing the part for most economical production.

Factors which must be considered in selecting a process include the design of the part; its shape and complexity; the size of the part and what areas must be held to mandatory tolerances; the material of which the part must be made, since some of the processes are limited to certain types of alloys; the surface finish necessary, and in what areas it must be maintained; the structural properties necessary in the resultant part; and the production quantity necessary, since a large part of the economics of manufacturing a part depend on this factor.

What is a Close Tolerance Casting?

If an engineer in a sand casting foundry were asked what he considered to be close tolerances, he might mention any figure from 1/16 or 1/32 in. upwards. If a machinist were asked what he considered to be close tolerances, he might mention any figure in the range of 0.0003 to 0.0005 in. Tolerances are all relative to the type of material forming process and the size and shape of the part under consideration. For purposes of this manual, the term "close tolerance casting" has been coined to mean castings where the as-cast dimensions on restricted areas can be held to tolerances in the range of ±0.001 to 0.005 in. per in., or ±0.010 to 0.020 in. on over-all dimensions.

It should be borne in mind that when a foundry specifies that commercial tolerances in this range can be held, this should not be taken as a guarantee that all dimensions of any part can be held to these limits. It merely means that if the part lends itself to that particular casting method, and if designed properly, dimensions on certain critical areas of the part may be held to these tolerances. Actual commercial tolerances possible on any dimension of a part can be accurately predicted only after consultation with the engineers in the foundry.

General Metallurgical Considerations

Shrinkage—Shrinkage of molten metal as it freezes is a prime consideration in holding accurate dimensions of castings. In normal sand casting operations, shrink rules may be used by foundries for each alloy. However, since shrinkage in a casting can alter a dimension anywhere from 0 to 0.025 in. or more, it assumes major importance when holding tolerances in the range of ±0.005 to 0.010 in., and general rules cannot be applied.

The degree to which a solidifying metal will shrink differs with each alloy used and the temperature at which it is poured. The degree and method in which the shrinkage will affect the dimensions of a casting depends on the design of the part, i.e., the amount of metal and the shape in which it is poured. These problems are not dealt with in this manual due to their dependence on individual design. They are essentially the problem of the engineer in the foundry. But it should be realized that the degree of accuracy of the casting depends to a large extent on the ability to calculate this shrinkage. And this problem is compounded by the considerations of expansion and contraction of patterns and molds as well as that of the casting alloy. In investment casting, for instance, when using wax patterns the engineer must consider the expansion of the pattern mold while pouring the wax, shrinkage of the wax pattern as it cools, the shrinkage of the mold as it is baked, and the shrinkage of the molten metal as it solidifies. All these are variables which may affect the accuracy of the part, and the ability to accurately estimate and allow for all these variables is the measure of a good foundryman.

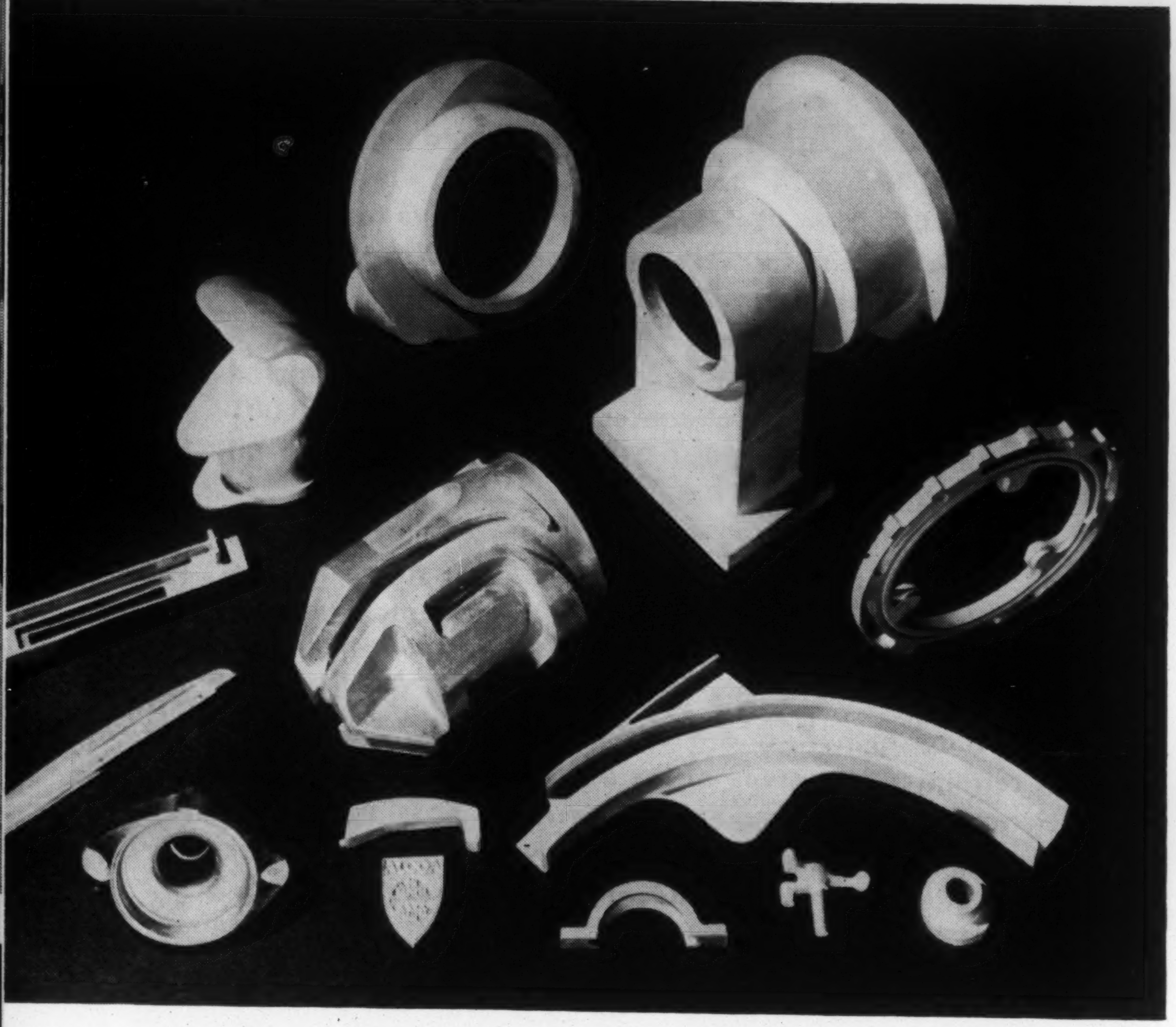
Solidification—The study of the mechanism of solidification of molten metals is a science, and there are still some unknowns under investigation. However, certain general rules aid in understanding the characteristics of castings produced by various methods. Maximum control over solidification of a casting is the ideal to be sought in each of the processes. Speed and direction of solidification contribute to the resultant properties of the casting and also are vital to the problem of proper feeding of all the areas. Optimum design conditions for casting are generally found when thin, finely detailed areas are farther away from the point of entry of the metal, so they can solidify first, and freezing of the metal will progress back toward the sprue through progressively heavier sections. Where the shape of the part will only allow feeding a heavier section through a thinner section, care must be taken not to allow the metal in the thinner section to freeze and shut off the flow of metal to the heavier section before it is completely filled. Control over feeding and solidification is implemented by the foundryman by the designing of proper gates, risers and vents as well as through the use of chills, cooling water, mold washes and the application of heat to certain areas of the molds.

The various types of mold materials used in the close tolerance casting methods play a large part in solidification characteristics of the castings. Mold materials with a higher degree of thermal conductivity, e.g., iron or steel, will remove heat from the molten metal more rapidly and produce a chilling effect on the metal. Rapid cooling will generally result in a finer grain structure and better physical properties. Mold materials with a lesser degree of thermal conductivity, e.g., sand or plaster, will act with more of an insulating effect and hold the heat in, slowing solidification of the metal. This will tend to produce larger grain structure though the slower cooling over a larger mass of metal may result in greater consistency in metallurgical structure. The problem then is one of design and heat control. The mold temperature and material ideally should be such that the metal solidifies fast enough to provide a fine grained structure, yet slow enough so that there will not be a chilled surface with hot spots of molten metal in the interior which may cause internal shrinkage defects in the casting.

As a general rule, the alloys used for casting will not greatly affect dimensional accuracy of a part, but may have an effect on the ease of obtaining this accuracy. In most of the processes some degree of control can be held over the speed of solidification. Where a sluggish metal is used, its freezing can be delayed until the finer detail is filled out.

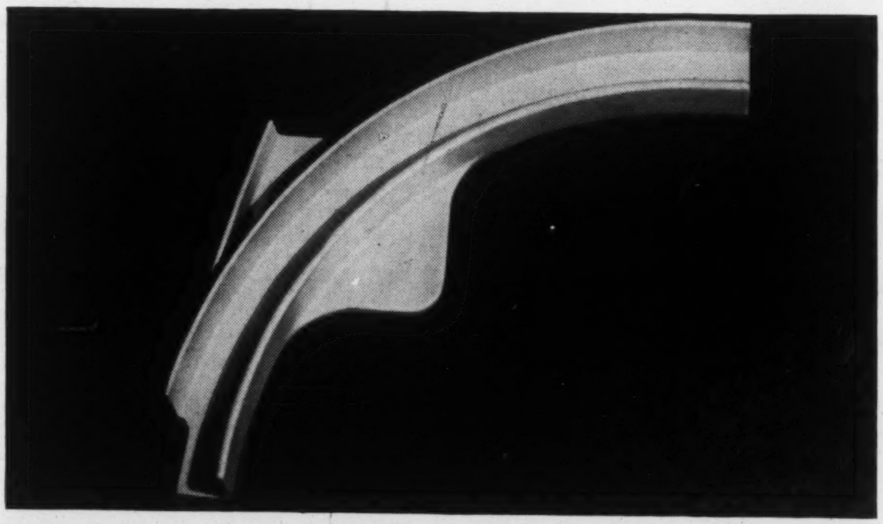
The only generalization that can be made about the relative fluidity of molten metals is that the ferrous are usually more sluggish than the nonferrous. The addition of silicon or nickel will generally increase the fluidity as demonstrated by the fact that many popular aluminum die casting alloys have silicon added to them.

Plaster Mold Castings



The small parts in foreground lend themselves particularly well to plaster mold casting, although the larger shapes can be readily cast also.

Case History



PART AND REQUIREMENTS — Aircraft Camera Track. A plaster mold casting in aluminum. The track is about 14 in. long with 1/8-in. sections throughout. Inside dimensions must be held within ±0.010 or less and consistent smooth finish of around 100 rms is necessary. Attractive appearance desirable.

ADVANTAGES OF CASTING—Part formed in one piece. Relatively low producton rate of around 50 per month can be maintained, providing accuracy and finish in as-cast condition.

The Method

In making a casting, the plaster mold material, an aqueous mixture of gypsum strengtheners and setting agents, is cast in a flask around matched metal plate patterns. When the plaster has set, the mold is removed from the pattern and baked to remove moisture and increase the permeability of the mold to air and gases. The mold is then assembled, with whatever cores necessary, and the metal poured. The mold is expendable and is broken away from the casting after solidification and cooling of the metal. Several types of plaster can be used to provide different degrees of permeability. The optimum material is that which will provide the necessary properties in the shortest possible set time, since this is one of the limiting factors on rate of production. Rather intricate coring can be achieved by using either plaster or sand cores or a combination of both.

Materials and Properties

Due to the temperature limitations of the mold material, this method is restricted to the casting of alloys with a melting point of 2000 F or lower.

These include aluminum, magnesium and some of the copper base alloys such as yellow brass, silicon bronze, beryllium bronze, aluminum bronze and manganese bronze. Some foundries claim that a restriction on lead content of the casting alloys must be set at a 1.5% maximum due to the reactivity of the lead with plaster; however, other foundries claim to have cast 50% lead alloys with no difficulty whatsoever. This should be the concern of the foundry since it deals with the type of plaster used, and should not trouble the user except as a point for discussion with the foundry.

Alloys containing silicon will generally lend themselves to the production of finer detail with better surface finish due to their higher fluidity which allows better feeding of all areas of the mold. When casting magnesium special plaster compositions and handling techniques are required as well as more ample feeding facilities in the mold. Generally the same degree of accuracy is obtainable in all of the alloys which can be cast. The difference lies in the relative ease of obtaining the desired results.

The mechanical properties of plaster mold castings are generally lower than those of permanent mold castings, although some foundries claim properties superior to other casting methods for some of the copper-ban alloys. By good design practice and proper casting techniques mechanical properties can be made to approach those of sand castings. The insulating effect of the plaster material promotes a coarser grain and generally lower tensile and elongation values. On the other hand, properties of the casting, though slightly lower, may tend to be more uniform throughout the casting. This is due to slower cooling which results in less a solidification time differential between those areas near the surface and those toward the interior of a casting section. With the exterior and interior areas of a casting section solidifying at more near the same rate, there tends to be a greater uniformity in grain size and microstructure through those areas.

Design Factors

Tolerances—Quoted tolerances will vary from foundry to foundry, but small dimensions on one side of the parting line can be held, where essential, to ±0.005 in. over-all. Some foundries stipulate ±0.005 in. for 1-in. dimensions, and an additional 0.001 in. for each additional inch. Size need not be the controlling factor if other dimensions and the design of the part is such as to allow concentration of efforts on one critical dimension. Across the parting line more liberal tolerances of ±0.010 in. should be allowed.

Size and Shape—The average size of plaster mold castings ranges from around ¼ lb up to 15 or 20 lb. Though the plaster material does not have a high degree of strength, larger parts may be cast if the part lends itself well to the process and the mold can be so constructed that thin areas of plaster do not directly support a major part of the weight of casting.

The process does not lend itself to casting parts with large, massive volumes of metal. The lack of thermal conductivity of the plaster material retards solidification, and in areas containing a large mass of metal this permits excessive grain growth. It also may bring about internal shrinkage, setting up voids or stresses which would lower the quality of the casting. It is desirable to limit section thicknesses to ¼ in. or less throughout to ensure relatively good consistent properties.

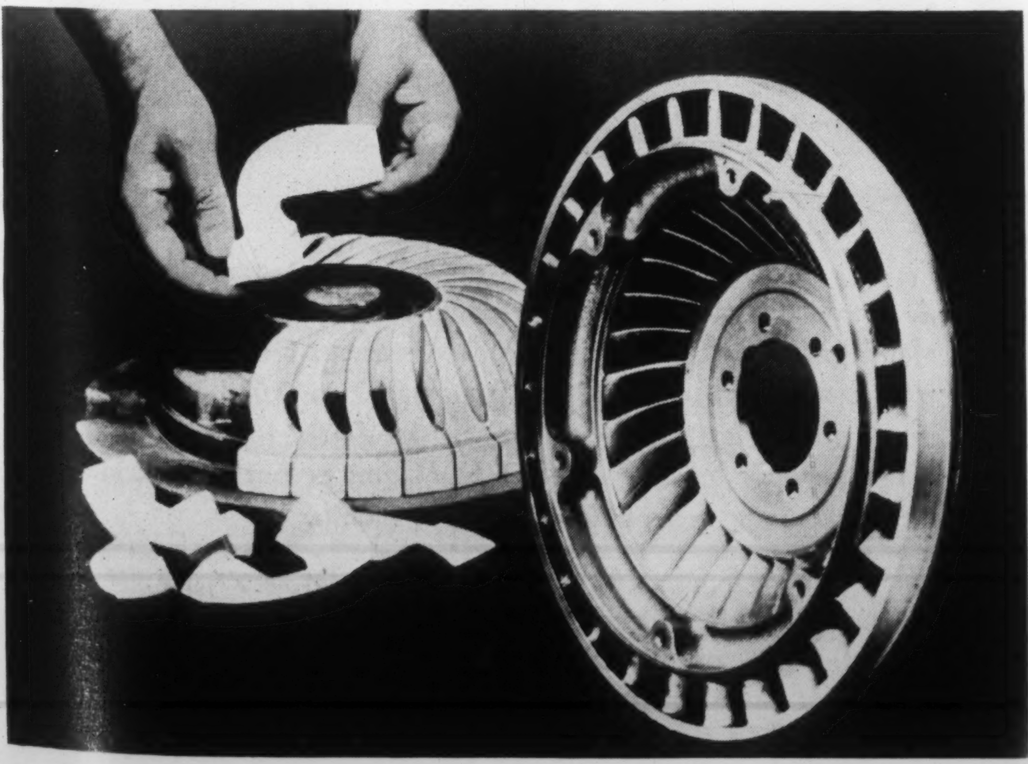
Other Considerations — Varying minimum wall thicknesses are claimed by different foundries. Generally on a 9-sq. in. section, the wall thickness should be at least 1/16 in., while with a ⅛-in. thick section some foundries claim unlimited areas can be cast. Another standard used by some foundries is a section thickness minimum of 0.040 in. on areas up to 2 sq in., 0.060 in. on areas of 4 to 6 sq in., and 0.090 in. on areas up to 30 sq in.

The minimum size hole that can be effectively cored is about ¼ in. in dia, though in these cases there should be a minimum of metal massed around the hole and it should be quite shallow. Though maximum radii are desirable on corners and angles for optimum properties in the casting, sharp angles with about 0.005 in. radii can be cast when mandatory. A notable feature of plaster-mold casting is the high as-cast surface finish obtainable. This can be reduced to around 50 or 60 rms when necessary.

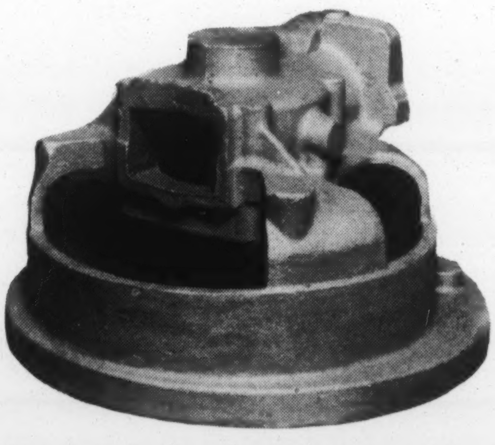
Permanent Mold Castings

The Method

A metal mold of two or more parts is made from a wooden pattern. The mold material is usually a quality controlled cast iron (Meehanite). Where welding is necessary the mold may be made of nickel-chromium steels. The mold is assembled, either on hinges or a straight draw, along with the coring necessary, and the molten metal is poured under gravity feed. After solidification, the mold is opened. Exact time of ejection is important as metal must be completely solidified to prohibit bleeding, yet not have cooled sufficiently to set up internal stresses.



Assembly of composite mold for torque converter part (see Composite Mold Case History) is shown here as plaster cores are placed in position on permanent mold.



Gray iron castings are now being produced in permanent molds, although the process was originally intended for nonferrous metals only.

There are various ways of coring permanent molds to obtain maximum complexity of shape. Metal cores are used wherever possible, and baked sand cores are used where retraction of metal cores is impossible. Where

After casting aluminum pistons in permanent molds the only machining necessary is turning, grinding and boring.

sand cores are used in conjunction with the permanent mold, the process is termed semi-permanent mold casting. The only difference insofar as accuracy is concerned is that the tolerances and surface finish obtainable in the sand core areas of the casting are limited to those of sand casting. Some foundries which are making complex parts find that a combination of iron, sand and plaster in a composite mold can most effectively produce the desired accuracy of fine detail, finish and metallurgical structure. All these various combinations of mold materials are covered in this section of the manual and characteristics of each will be discussed where they differ from those of normal permanent mold casting.

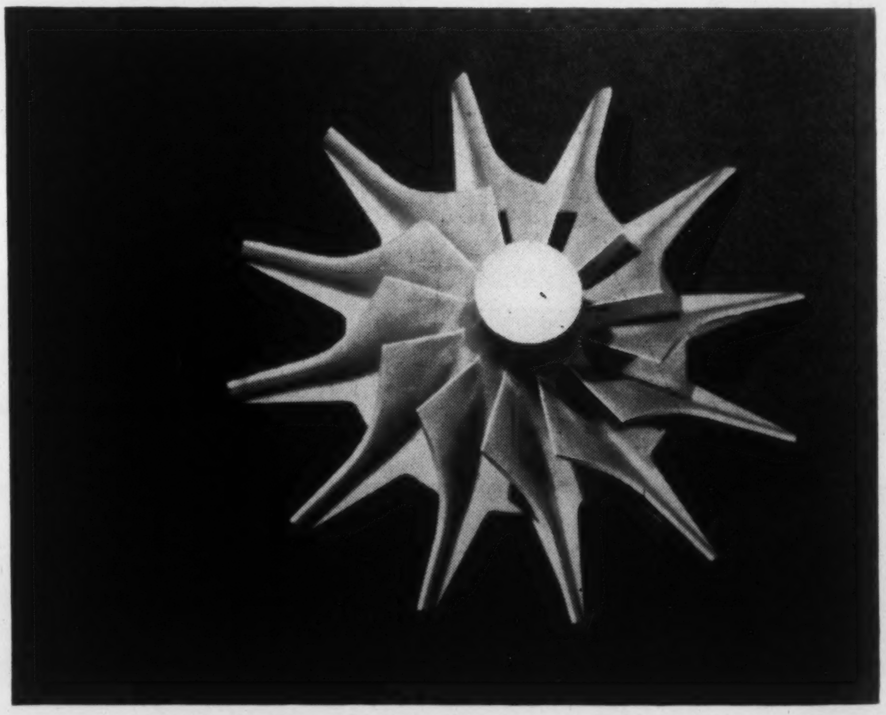
Materials and Properties

Due to the relatively low temperature characteristics of the mold material the process is limited to the lower melting point alloys. Aluminum alloys are the most commonly cast. Copper-base alloys, magnesium and more recently, gray iron are also cast in permanent molds. It should be borne in mind that when casting the higher temperature materials the mold life will be shorter than with aluminum and magnesium alloys.

Though gray iron castings produced by the permanent mold process have a higher degree of accuracy than those cast in sand, they represent a rather borderline case in respect to the scope of this manual. The optimum in casting size ranges from ½ to 12 lb in weight and from 2 in. in dia by ½ in. in thickness to 10 in. in dia by 1 in. in thickness. On castings of this size, over-all tolerances in the range of ±0.025 in. can be held. Of course, these tolerance depend on the size and configuration of the part, and under optimum design conditions, better tolerances may be held. Casting to this accuracy can provide substantial savings in the production cost of a part; however, due to the limitations established here, further discussion of permanent mold casting will be confined to the nonferrous metals.

The relatively high mechanical properties of permanent mold castings are due to the chilling effect brought about by the high thermal conductivity of the mold material. This results in metal of fine grained, dense structure. Control over solidification of the molten metal is exercised originally by designing gates, risers, and vents to obtain optimum feeding conditions. Also various types of ceramic mold washes, which are used to insure proper parting of the casting from the mold, can be applied in varying thicknesses to impart desired degrees of insulating effect to the mold. If further control is necessary, sectional heating or chilling of the mold can aid in maintaining even closer control. Molds may be preheated to tempera-

Case History



PART AND REQUIREMENTS — Supercharger Impeller. A permanent mold casting in aluminum. The part must withstand 40,000 rpm spin test. Impeller is about 5 in. in diameter with blade thickness tapering from 0.060 to 0.020 in. Tolerances on thinner areas of blades must be held to ± 0.005 in. Blade surfaces must be finished to 60 rms or better. Production rate ranges from 500 to 1000 per month.

ADVANTAGES OF CASTING—Since plaster cores are used, process should be termed semi-permanent molding, but part illustrates the good mechanical properties obtainable with permanent mold casting. Plaster cores used to form critical dimensions and good surface on blades.

tures ranging from around 700 to 800 F, and the selection of the proper mold temperature for pouring is one of the factors which makes casting an art. If the mold is too cold the metal will freeze too rapidly and will not flow; if the mold is too hot, solidification will be too slow, and the properties of the casting may be impaired.

Heat treating or aging can be used to gain the optimum physical properties of the material. This will depend to a certain degree on the shape of the casting and the areas of critical dimensions, since heat treatment will in some cases bring about a certain amount of distortion.

Design Factors

Tolerances—Normal minimum tolerances on permanent mold castings may run around ±0.015 in. over-all on small parts, though more should be allowed where possible. On small dimensions of 3 or 4 in., some foundries claim over-all tolerances can be held to ±0.006 to 0.008, though some others do not agree that this is economically feasible. A careful cost evaluation should be made before specifying tolerances in this range. Where a high degree of accuracy is necessary, an additional 0.010 in. may suffice across the parting line, but in many cases it will not prove to be economically practical. Wear on the mold due to continued casting will eventually be reflected in the dimensional accuracy of the castings. The usable life of a mold is dependent on the accuracy required, the melting point of the alloy cast, the amount of draft allowed, and other foundry and design variables.

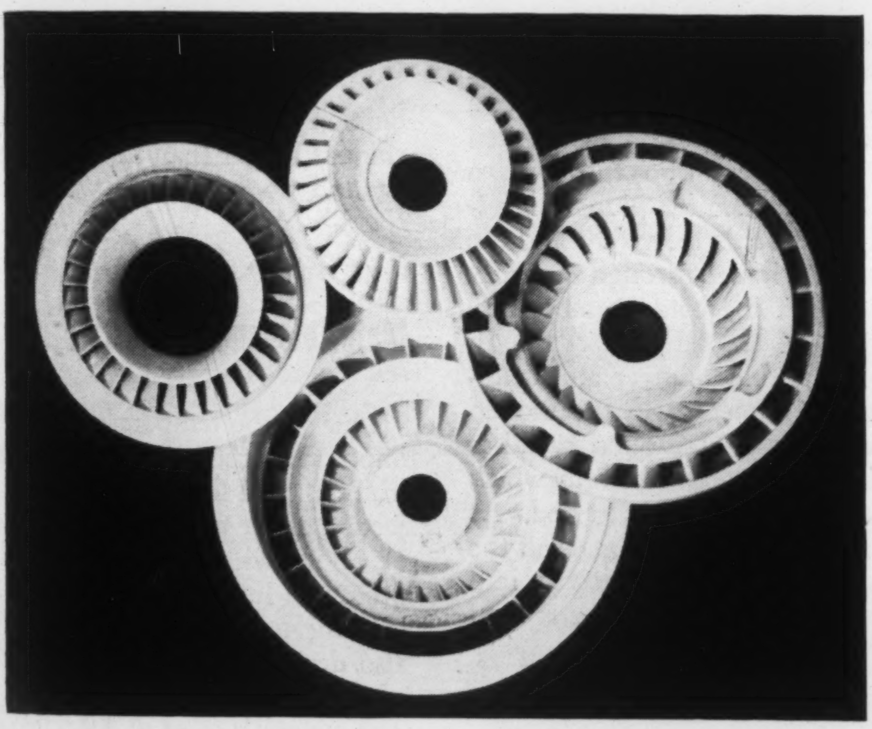
One of the difficulties encountered in holding close tolerances in permanent mold work is caused by the ceramic mold wash, which is usually sprayed on in thicknesses of 0.005 to 0.015 in. If applied carelessly in a critical area it may consume several thousandths of a stringent tolerance. This can also be a cost factor, since the closer the tolerance specified the greater the care that must be taken in applying the wash.

Composite Molds — In restricted areas where closer tolerances are necessary than can be held with the plain permanent mold, an advantage may be gained by investigating the use of composite molds. Some foundries have done a substantial amount of developmental work in using this relatively new technique. In the design of some castings, plaster sections can be incorporated in the mold to gain greater accuracy or a higher degree of surface smoothness in critical areas. It has been found that the insulating property of the plaster can also be used in this type of mold to control the solidification of the molten metal to gain the optimum in metallurgical quality. The plaster is generally used in those areas where solidification should be delayed to help fill out fine detail or thin sections, while the iron of the permanent mold provides the chilling effect where it is required on the more massive areas. In some cases sand may also be incorporated where areas do not require a high degree of accuracy or finish. By proper engineering of the composite mold, it is possible that the thermal conductivity of the sand, which falls between that of plaster and iron, can be utilized to gain the optimum in progressive solidification of the molten metal. Though some foundries have done more developmental work on this technique than others, it is still a relatively new process and all its ramifications have not been fully explored.

Sizes and Shapes—The only limitations on the size of a permanent mold casting are the foundry facilities available for melting, pouring and handling the molds. According to the estimate of one foundry, 70 to 80% of all permanent mold castings produced today range from 1/10 to 10lb in weight. There does, however, seem to be a trend toward larger size castings, possibly due to the technological developments bringing about greater mechanization of foundries, and with it the ability to handle larger quantities of materials and heavier equipment.

Other Considerations — Since the

Case History



PART AND REQUIREMENTS — Automotive Torque Converter Parts. A composite mold casting (iron-sand-plaster) in aluminum. The diameters range from 7 to 15 in. Vane areas require surface finish in 100 rms range and dimensional accuracy of ± 0.010 or less. Vanes taper from 1/4 in. to 0.040 in. in thickness. Consistently high mechanical properties required. Production rate is around 10,000 per month.

ADVANTAGES OF CASTING—Each part formed in one piece. Varying masses of metal require different chilling effects. Plaster mold used in vane areas for finish, accuracy and slower solidification to fill fine detail. Sand and iron regulates solidification in heavier, non-critical areas. Turning of hub is only machining operation required.

draft angle allowed on dimensions of a permanent mold casting affects mold life and foundry operations, it therefore may substantially affect the cost and quality of the casting. The more liberal the draft angle, the less damage is done to the refractory mold wash during ejection of the casting, and the higher the degree of structural uniformity from casting to casting. Also the less seizure of the mold during ejection of the casting, the longer the mold will last. Two or three degrees is about as low an angle as is feasible. One degree is really too small, though it may be enough on some outside areas.

Large radii on fillets are important to minimize the possibility of directional solidificaton and the resultant decrease in strength and accentuation of cracks in the casting. Minimum section thickness desirable in permanent mold castings is 1/8 in., though in restricted, small plane areas a thickness of 0.090 to 0.100 in. may be possible depending on the design of the part. Holes may be cored down to 3/8 or 1/4 in. in dia., but the maintenance cost of cores might be higher than the cost of drilling the holes.

Surface smoothness generally obtained runs around 100 to 125 rms, though a better finish may be obtained, where necessary, by polishing that area of the mold and taking care in applying mold wash. The main limitation is the mold wash used; its presence is detectable on the finish casting.

Special Processes

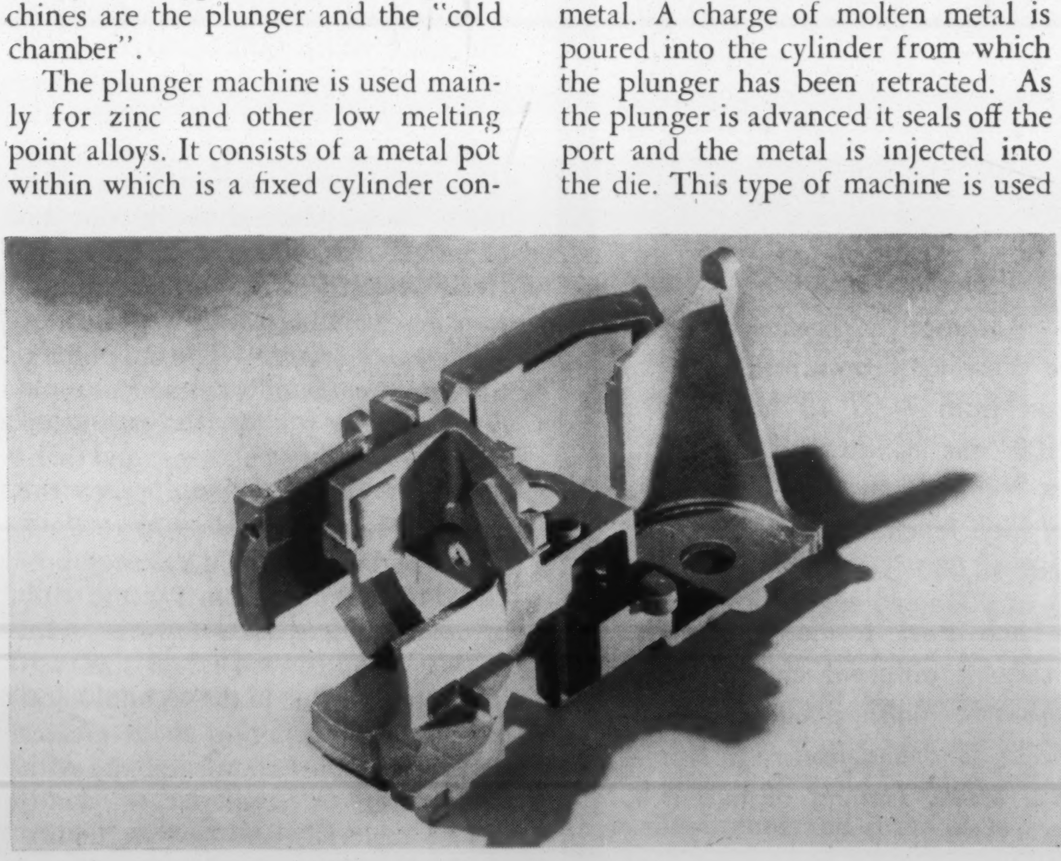
Though some companies have shown interest in centrifuging or spinning in conjunction with permanent mold work the results are problematic. The process involves spinning of the permanent mold around an axis which does not pass through the casting itself. Some companies claim the centrifugal force developed aids in filling out fine detail and thin sections, providing a better surface finish and a denser metallurgical structure. However, other firms feel that the advantages when casting the light, nonferrous metals are negligible, though some possibilities may exist for specialized applications in the heavier metals such as copper-base alloys or iron. This must be left up to the individual engineer in determining whether any advantages may be gained by using the process in casting his specific part.

Die Castings

The Method

Die casting involves the forcing of molten metal into a steel die set under pressures which may range anywhere from 1500 to 25,000 psi. The degree of pressure will vary with the injection method and the alloy used. After solidification the die is opened and the die casting ejected. The two commonly used types of die casting machines are the plunger and the "cold chamber".

The plunger machine is used mainly for zinc and other low melting point alloys. It consists of a metal pot within which is a fixed cylinder connected by a spout to the die. When the plunger in the cylinder is retracted, a port is uncovered, allowing molten metal from the main pot to flow into the cylinder. When the plunger is advanced, the port is closed off and the molten metal forced through the spout into the die. The cold chamber machine differs from the plunger type in that the injection plunger and cylinder are not immersed in the molten metal. A charge of molten metal is poured into the cylinder from which the plunger has been retracted. As the plunger is advanced it seals off the port and the metal is injected into the die. This type of machine is used primarily with the higher melting point alloys, i.e., aluminum, magnesium and copper-base. The low melting point alloys may be used, but the production cycle on the cold chamber machine is longer than that of the plunger, and no advantage would be derived.



Produced at a rate of approximately 60 per hr in a single cavity die, this aluminum instrument housing is indicative of the complicated shapes which can be die cast successfully.

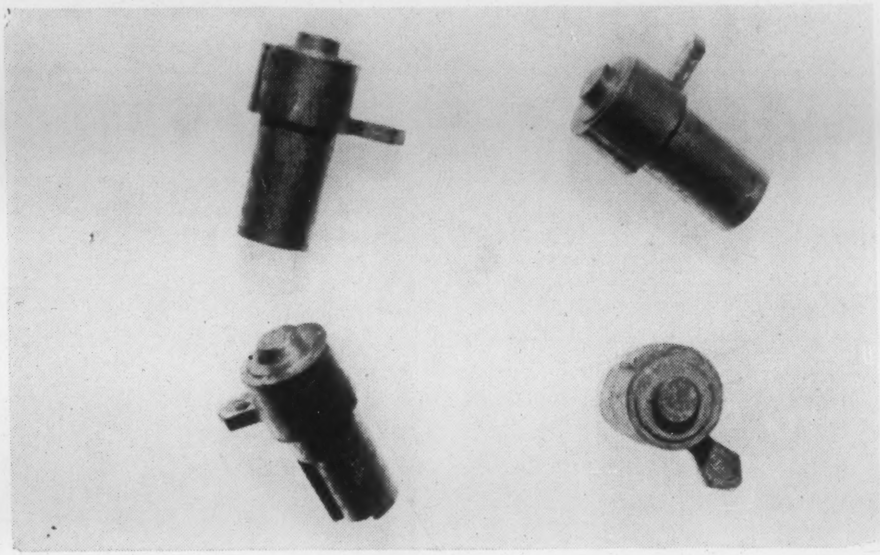
Materials and Properties

Due to the temperature limitations imposed by the use of steel as the die material, and the rapid mechanical injection of the molten metal, the choice of alloys which can be used in the process is limited to those with a low melting point. Maximum fluidity is also desirable to speed the filling out of fine detail and thinner sections. The materials most widely die cast are the zinc alloys, followed by aluminum, magnesium, copper, lead and tin. These materials offer a rather wide range of selection as far as mechanical and physical properties are concerned.

Zinc alloys are among the easiest to die cast, possessing melting points in the range of 700 F. Zinc die castings generally provide high values in ductility and impact strength and have the additional advantage of being easily plated with nickel or chromium. Tensile strengths in the range of 35,000 to 45,000 psi may be expected on die cast tensile test specimens in the standard alloys used.

Aluminum and magnesium alloys, whose melting points fall in the vicin-

Case History



PART AND REQUIREMENTS—Refrigeration Defrosting Cam. Die Cast in zinc, the cam shaft is approximately 1 in. long. Total cam rise is 0.030 in., with varying degrees of lift angle. Tolerance in each 10-deg area is ±0.0015 in. on dimensions from fixed reference point. Total tolerances including those on reference point and those on cam surface are ±0.004 in. Dimensions on shaft ends must be held within +0.002, −0.001 in. Cam surface must have high degree of smoothness to ensure accurate operation of refrigeration control. Production rate is around 100,000 per week.

ADVANTAGES OF CASTING—Die cast part replaces 4 piece assembly; subsequent machining is tapping 1 hole. Tolerances can be held and high production justifies cost of casting die.

ity of 1100 to 1200 F are almost interchangeable insofar as dies and casting equipment are concerned, though certain precautions are necessary with the latter, and more ample feeding facilities are necessary in the die due to the rapid freezing characteristic of the metal. The aluminum alloys offer good corrosion resistance and dimensional stability. Tensile strengths in the range of 35,000 to 45,000 psi can be expected on die cast tensile test specimens in the standard alloys used. In the magnesium alloys tensile values will be slightly lower, ranging from 30,000 to 35,000, but offering a slightly better strength-to-weight ratio.

The bronzes and brasses have high corrosion resistance and offer the highest physical values of any of the die casting alloys, tensile strengths ranging generally from around 50,000 to 100,000 psi, or more, on test bars. They are, however, more difficult to die cast and the relatively high melting point of the alloys (around 1600 F) will result in a shorter die life.

Lead and tin, though easily die cast, have poor mechanical properties (about 8000 to 14,000 psi tensile) and are not used extensively for die casting except for specialized applications.

In die casting as in permanent mold casting, an advantage is derived from the high thermal conductivity of the steel used in the die. The resultant chilling effect promotes fine grained metallurgical structure. While die castings are subject to varying degrees of porosity, proper engineering of the casting and the die may confine it to areas of the part where it is not critical. Also, relatively recent developments in the process have made pressure tight applications of die castings rather common.

Design Factors

Tolerances—In die casting, the alloys used will affect the accuracy obtainable. Typical tolerances on dimensions up to 1 in. are ±0.003 in. in zinc, ±0.004 in. in aluminum and magnesium, and ±0.007 in. in the copper-base alloys. On dimensions of 1 to 12 in. ±0.001 in. per in. is obtainable in zinc, ±0.015 in. per in. in aluminum and magnesium, and ±0.002 in. per in. in the copper-base alloys. Over 12 in., ±0.001 in. per in. tolerances are held in zinc, aluminum and magnesium, and since most of the copper-base alloy die castings are smaller than this, no tolerances are stipulated for those alloys. These tolerances, of course, will depend on the design of the part; and across die parting lines or where fits of cores or slides are encountered, larger variations must be allowed.

Size and Shape—The size of die castings, being limited only by the machine used, varies from fractions of an ounce to 75 lb in aluminum and 200 lb in zinc, on the newest machine. The complexity possible in die casting is relatively high. Slides, movable die sections, cores and cores-within-cores allow a great degree of intricacy, though it is somewhat limited by the need for steel coring which must be withdrawn from the die casting. For instance, some shapes are possible in semi-permanent mold casting which could not be die cast since sand cores may be used in the former where the shape of the part would not allow withdrawal of metal cores.

Other Considerations — Recommended minimum draft on side walls of die castings in in. per in. of length is, 0.005 for tin and lead, 0.007 for zinc, 0.015 for aluminum, 0.010 for magnesium and 0.020 for the copper-base alloys. Though these are recommended minimums, where possible a larger draft allowance may result in longer die life and a reduction of operational problems.

It is desirable where possible to hold sectional thicknesses to less than 1 in., though larger sections may be handled where necessary. With the larger sections the danger of encountering internal shrinkage is increased. On the smaller die castings minimum section thicknesses may be held to 1/32 in. in tin and lead, 0.025 in. in zinc, and 0.050 in. in aluminum, magnesium and copper. On the larger die castings, minimum wall thicknesses may generally be held to 1/16 in. in tin and lead, 0.050 in. in zinc, 0.080 in. in aluminum and magnesium and 0.090 in. in copper.

Holes may be cored down to 1/16 in. in dia, though this will depend to some extent on the mass of metal about the hole and its depth. Though coring will add to the expense of the die, with the large production quantities encountered in die casting, this additional cost may well be worthwhile when considering the expense of drilling the same quantity of holes. In die casting, as in other casting processes, maximum radii are desirable on corners and angles to obtain the optimum in casting quality. The typical as-cast finish on die castings may range from 100 to 125 rms, though this may be reduced to around 60 rms by polishing certain areas of the die.

Shell Mold Castings

The Method

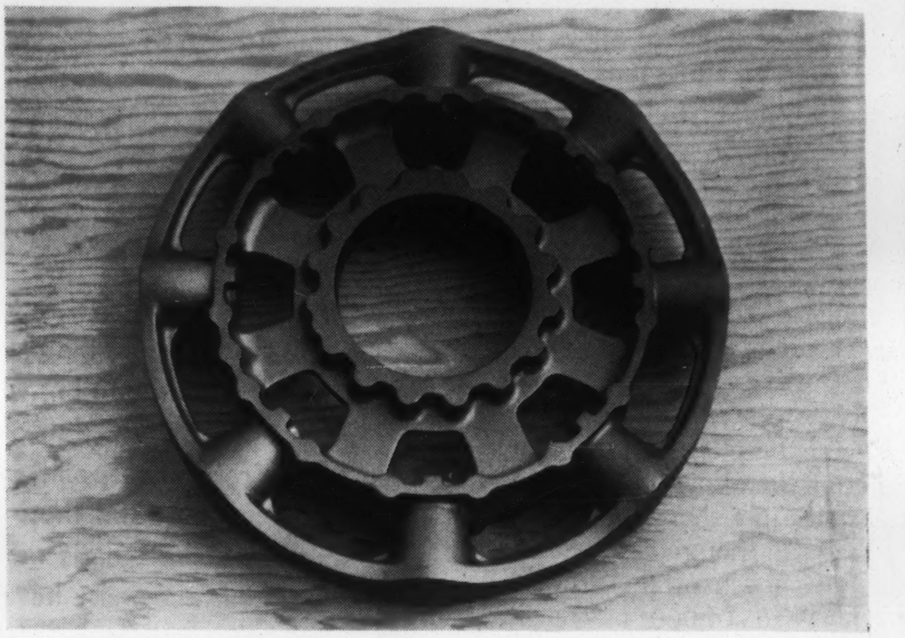
A mixture of sand and a two-stage phenolic resin is baked around a pattern (generally made of aluminum, iron or bronze) in a mold-making machine. The resultant shells are assembled by gluing or bolting, or a combination of both, and in some cases the shell is packed in a flask with backing material before pouring. The metal is melted and poured, and after solidification, the shell is broken away from the casting. With the use of baked sand cores, quite intricate and substantial coring is possible with the process, and for greater stability than the core print provides, the sand core can be glued to the mold wall. Additional possibilities are expected with the development of shell molded cores, which would provide greater stability and a greater degree of complexity of shape.

Materials and Properties

The shell mold process can handle any alloy that can be cast in sand, though some may be more difficult than others. Some problems exist with the low carbon steels, high leaded brasses; high tin bronzes and magnesium; however, they are not insurmountable. The low carbon steels tend to produce surface defects. Sweating of tin and lead in bronzes and brasses with high percentages of these alloying elements has caused problems, and the reactivity of magnesium with oxygen and silica sand must be countered with inhibitors or mold washes.

Mechanical properties of shell mold castings are comparable to, or better than those of sand castings. Better properties are due to closer control generally exercised over the various foundry variables. Also, the shell mold is baked dry, and the lack of moisture slightly increases the insulating effect of the mold. With the masses of metal generally dealt with in this process, the slightly slower cooling tends to produce more uniformity of structure throughout the casting. The high permeability of shell molds minimizes the porosity and voids in the solidified metal by allowing air and gases generated during pouring to escape through the shell. Subsequent heat treatment can be used to gain optimum properties of the heat treatable alloys.

Case History



PART AND REQUIREMENTS — Jet Engine Support Ring. A shell mold casting in austenitic chromium-nickel steel, the ring is approximately 15 in. in diameter, 2½ in. thick. Dimensions across the bolt circle (approximately 11 in.) must be held within ±0.010 in., while those across parting line are not critical. Surface finish desired is approximately 125 rms. Inspection requirements include 100% x-ray and 100% zyglo as well as normal visual procedure.

ADVANTAGES OF CASTING—Major factor is the high quality necessary from casting to casting. Stringent inspection requirements call for close control over casting operation.

Design Factors

Tolerances—Since shell molding is still a relatively new process, all its possibilities have not been explored. However, in commercial production, tolerances are now being held on 1 in. dimensions within ±0.003 to 0.005 in., while according to some foundries ±0.002 in. can be held on small dimensions under optimum conditions. On larger parts over 3 in., smaller inch per inch tolerances can be held. In one instance an over-all tolerance on an 11 in. dimension was held to ±0.010 in. At this point, it is difficult to say what standard tolerances will be established for the process. Where dimensions fall across a parting line of the mold, tolerances should be doubled as a rule, or at least an additional 0.010 in. should be allowed.

Size and Shape—The size of castings produced by shell molding is limited by the capacity of the mold-making machine. At present in this country, molds up to 60 in. square can be made. According to reports, castings have been poured in Europe up to 800 lb. However, it must be remembered that with the larger castings, a greater amount of resin binder is necessary to withstand the weight of the casting alloy, and this will increase the cost of the process. There seems to be general agreement that the logical sizes to date range from 20 to 30 lb in the ferrous alloys.

As was mentioned before, the complexity of shapes which can be shell molded is relatively high. The slower solidification also aids in filling out fine detail and thin sections of the casting. The complexity is mainly limited by the need for withdrawing the pattern from the mold. Multi-part patterns may be made which will increase the range of complexity, but this will also increase the pattern cost and reduce the production rate.

Other Considerations — Draft angles are not as critical as in some other processes; ½ deg is usually sufficient. Small plane areas can be cast successfully down to 1/16 in. in thickness. One foundry has successfully cast an alloy steel section 8 by 60 in. to a 3/16 in. thickness. However, obviously these are not desirable from a design standpoint, and where they are necessary a gradual transition from thin to thick section should be made.

The minimum size hole that can be cored effectively is around ½ in. in diameter. With a hole this small the mass of metal around it should be kept to a minimum and the hole should be shallow. Smaller holes can be cast by forming a nipple in the shell material itself rather than by separate coring. Where a small hole must be incorporated in the design, particular care should be taken in deciding whether drilling the hole might not be more economical than coring it in the casting. Sharp angles as always should be avoided; however, relatively sharp angles and corners can be obtainable where necessary in alloys which are not notch sensitive.

The as-cast surface finish is one of the advantages of the processes. Under normal conditions finishes of 125 rms can be maintained in the ferrous alloys without difficulty. In 410 steel, 60 rms has been attained, and even better values can be achieved in the nonferrous alloys. One of the controlling factors in surface finish is the weight of the casting. A finer finish can be obtained with finer sand, but the finer the sand the weaker the mold. The optimum conditions for fine surface on a casting are obtained when the finest sand which will withstand the hydrostatic pressure of the molten metal is used.

Shell molding the garbage disposal shredder ring (left) substantially reduced the machining previously necessary on the sand cast ring (right). The high chromium alloy ring is turned out at a high production rate with tolerances on the 6 in. diameter held to ±0.010 in. over-all.

Investment Castings

The Method

A pattern of the part to be produced is cast in either wax, plastic or frozen mercury. A refractory slurry is then cast around, or dipped on the pattern and after it has set, the pattern is melted from the mold. The mold is then baked and the molten metal is poured into the cavity. After solidification the mold is broken away from the casting.

Each of the pattern materials—wax, plastic and frozen mercury—has characteristics which make it most suitable for the production of certain types of parts, or allow it to meet certain production requirements.

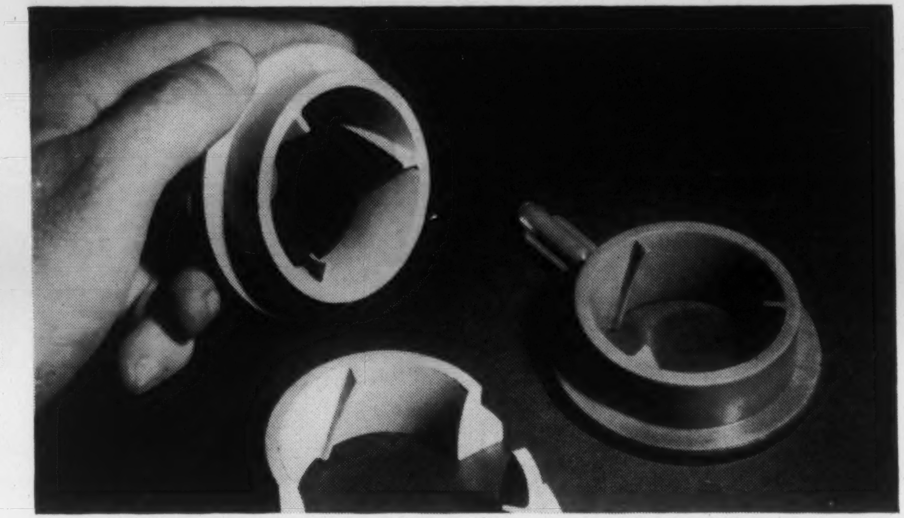
The main feature of plastic patterns, usually of polystyrene, is the higher rate of production possible. The pattern is made by injection molding, allowing faster production and, due to the greater dimensional stability of plastic in comparison to wax, patterns can be made in advance of use and stored with less breakage, warpage or disfigurement. The injection molding process does limit the shape of the part to some degree. Since high pressures are used in injecting the plastic material, the coring possibilities are limited.

Wax patterns, the early use of which gave prevalence to the term "lost wax process", allow greater flexibility of design than plastic. Since the wax is injected under relatively low pressures and dies are operated manually, a greater variety of coring is permitted. Dies for wax patterns are generally less costly than those for plastic or frozen mercury.

Frozen mercury as a pattern material is relatively new in the field. Though it is more expensive to work with since refrigeration is necessary (—70 to —135 F), it has several advantages due to the unique properties of the material. The low volumetric shrinkage of mercury allows the ceramic mold to be dipped on in thicknesses of ⅛ to ¼ in., whereas with wax and plastic, the investment material is cast solid in a flask around the pattern. Casting the molten metal in a thin shell permits greater control over metallurgical structure of the casting. The low volumetric shrinkage coupled with the dimensional stability of frozen mercury also allows larger sized castings to be produced.

Two pieces of frozen mercury can

Case History



PART AND REQUIREMENTS — Fuel Pump Diffuser Ring. An aluminum investment casting using a wax pattern. Helical blades on inside of the ring must be held to 1/2 deg of true location. Dimensions of ring i.d. (1.756 in.) must be held within ± 0.003 in., and surface finish on internal area must be 90 rms or better. Part must be 100% x-ray sound with no internal or external porosity.

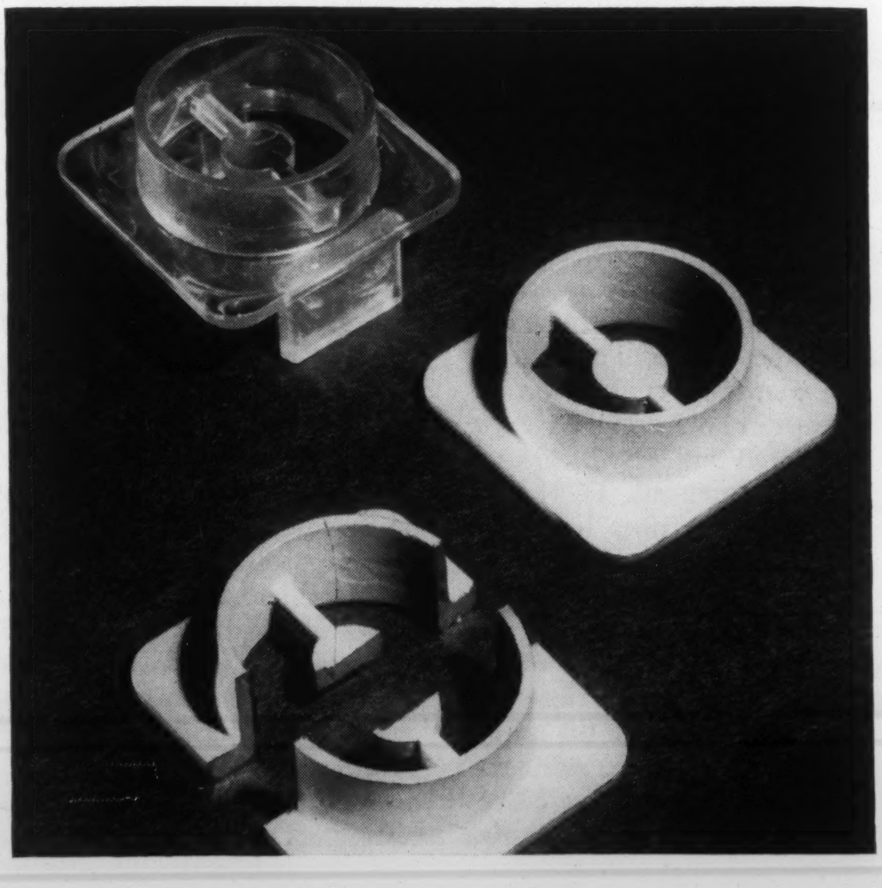
ADVANTAGES OF CASTING—Finish and dimensional accuracy can be held without machining. Production quantity of 1500 to 2000 per month may be easily met with wax pattern investment casting.

be joined merely by pressing them together. The pressures needed are relatively slight, and the resultant bond good. This is called "booking", and is, in effect, solid state welding. This property of frozen mercury offers obvious advantages in designing a complex pattern for investment casting.

Materials and Properties

Of the six methods of close tolerance casting, investment casting is matched only by shell molding in the range of alloys which can be cast. Any castable alloy can be investment cast. It is understandable then that a large share of the investment castings being produced are in the high melting point ferrous alloys, copper alloys and special high temperature nonferrous alloys, as well as in the aluminum and magnesium alloys. Though the same general degree of accuracy or fine detail is obtainable with all the alloys cast, it is easier to obtain these results with the nonferrous than with the ferrous, due to their higher fluidity and lower melting point which allows certain advantages in casting technique.

Case History



PART AND REQUIREMENTS — Fuel Filter Seat. Using plastic pattern, part is cast in 303 stainless steel. It must function under fuel pressures up to 300 psi. Dimensions on i.d. (1.270 in.) and diameter of circular piece in center of part (0.438 in.) must be held to ± 0.003 in., since valve face makes contact with them.

ADVANTAGES OF CASTING—Stainless steel is cast to accuracy which can be held without machining. Production rate of 3000 to 5000 per month justifies expense of plastic die.

The mechanical properties of investment castings are generally high. Some foundries claim that in the heat treatable grades properties roughly comparable to those of wrought materials are obtained. As-cast properties of the castings can be controlled to some extent by regulating the pouring temperature of the metal and of the mold and thereby controlling the speed of solidification of the metal. Control is also maintained by the proper design of gates and risers, etc. The majority of castings made of heat treatable alloys are heat treated to gain desired properties or annealed to aid in machinability. With proper heat treating techniques, distortion of the castings may be limited so as not to affect the tolerances unduly.

Design Factors

Tolerances — Quoted commercial tolerances will vary from foundry to foundry, and according to most, this is the area in which investment casting has been somewhat oversold. General tolerances obtainable range from ±0.003 to 0.005 in. per in. Some foundries state they can hold ±0.002 in. per in. on small, restricted dimensions. One foundry quotes general tolerances of ±0.003 in. for dimensions under $\frac{1}{2}$ in., ±0.005 in. on dimensions of $\frac{1}{2}$ to 1 in., and ±0.005 in. per in. on dimensions over 1 in. Here again it should be pointed out that the closer the tolerance, the higher the cost of the casting. Change in dimension across the parting lines caused by the pattern dies can be made negligible in most cases with wax and frozen mercury; but more allowance must be made with plastic due to the injection pressures used.

Sizes and Shapes—Investment castings made in wax or plastic range from fractions of an ounce to around 25 lb, though increasing specified tolerances may allow larger sizes. With frozen mercury, the size of the castings is limited by the facilities of the foundry. Castings with frozen mercury patterns have been made weighing over 100 lb. The average weight of most investment castings ranges from about 1 oz to 3 or 4 lb.

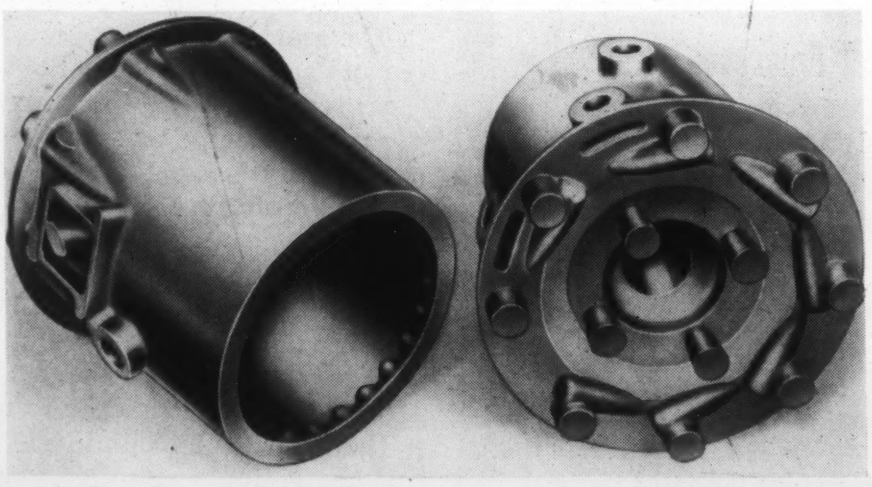
The process is not generally conducive to the production of parts with large, massive areas of metal, since the mold material does not have a high degree of thermal conductivity and will delay solidification. In massive areas this delay might be sufficient to allow the growth of a coarse microstructure in the central areas and result in inferior mechanical properties of the casting as a whole. Most foundries agree that it is desirable to keep section thicknesses down to 1 in. or below, though thicker sections may be handled where necessary. The mold material used with frozen mercury has a higher degree of thermal conductivity allowing heavier sections to be cast effectively.

Of the three pattern materials, plastic allows the lowest degree of complexity, while frozen mercury and wax are roughly comparable. Since the patterns are melted from the molds, the only limitation on shape is derived from the need for withdrawing the pattern from the pattern die. In constructing a one piece pattern, highly intricate coring is allowed by the insertion of a core made of the same material as the mold which will be cast around the pattern. When the pattern is removed from the die, the core is still in the pattern, and when the slurry is cast around the pattern and the pattern melted out, the core remains inside the mold fixed to the mold wall.

Where the shape of the part will not allow the pattern to be made in one die, the pattern may be made in several segments, removed from the dies and joined together. Though patterns in any of the three materials may be made in sections and assembled, frozen mercury lends itself most readily to this method. Joining plastic sections involves a gluing or cementing operation. In working with wax, the areas to be joined are softened by heat and "welded" together. With careful workmanship this method can produce a high degree of accuracy. The booking property of frozen mercury mentioned before allows the greatest ease of joining and generally assures a high degree of dimensional accuracy.

Other Considerations—Investment casting requires no draft in the pattern die. The three pattern materials, when cooling, shrink away from the mold and are removed without difficulty. The minimum section thickness on small plane areas may range from 0.030 to 0.050 in., though most

Case History



PART AND REQUIREMENTS — Circular Steel Housing. Using frozen mercury pattern, part is cast in 21 chromium, 9% nickel. The housing has a diameter ranging from 7 in. at one end to 9 in. at other, and an over-all height of around 8 in. The wall thickness which amounts to 160 sq. in. is 0.100 in., held to ± 0.010 in. General tolerances held are ± 0.010 in., although on some dimensions tolerances are held to ± 0.005 in. High degree of concentricity must be maintained on part, and typical surface finish of 100 rms must be produced.

ADVANTAGES OF CASTING—Concentricity and large thin walled area can be maintained with close dimensional accuracy. Booking of mercury pattern is used to form complicated shape. Surface finish can be attained without secondary finishing.

General Characteristics of

Casting Type	Choice of Materials[1]	Tolerances, in./in.		Cost Factors			
		Normal	Possible on 1 in. dimen.	Labor	Equipment (dies, patterns, and/or machines)	Casting Materials	Typical Rate of Production Pouring[2]
Precision Sand Casting	(4)–Aluminum, magnesium and bronze alloys. Use of ferrous uncertain as to dimensional accuracy.	±0.005	±0.003	Medium high	Low	High	300 per mo.
Shell Molding	(1)–Any castable alloys, though mostly ferrous being cast.	±0.005 ±0.010 across parting line	±0.003	Low	Medium high	Wide range	60 per hr
Plaster Mold	(5)–Aluminum, magnesium and some copper-base alloys. (Melting point below around 2000 F)	±0.005 ±0.010 across parting line	±0.005	Medium high	Low	High	4–5 per hr
Permanent Mold	(3)–Aluminum, magnesium and copper-base.	0.015 in. overall on small dimensions.	±0.005	Medium	High	High, nonferrous; Low, gray iron	30 per hr
Die Casting	(5)–Aluminum, magnesium zinc, some copper-base alloys, tin and lead.	±0.005 ±0.010 across parting line	±0.002-Zn ±0.003-Al	Low	High	High	75–150 in Al, Mg, Cu-base 300–350 in Zn
Investment	(2)–Any castable alloy.	±0.005	±0.003	High	Varies with quality of pattern die necessary.	Wide range	Generally low. Higher with plastic pattern.

1. Numbers represent relative range of choice in selection of materials, (1) = widest choice, (2) = narrower choice, etc.

foundries would prefer to maintain a minimum of 0.080 to 0.090 in. With a shape such as a small impeller blade, the tapered edge may be reduced to 0.015 in., and this is not uncommon. Generally, holes may be cored in nonferrous alloys down to about 1/16 in. in dia, though in thin sections smaller ones may be quite feasible. In the ferrous alloys, diameters are limited to around ⅛ in. This holds true in cases where there is a minimum of massed metal around a shallow hole. As in the other casting processes, fillets are desirable, but where necessary, angles and corners may be held to a minimum radius of 0.005 in.

The normal as-cast surface finish on investment castings may range from 60 to 100 rms. With frozen mercury patterns, values of 40 rms are said to be easily obtainable under optimum conditions.

Special Processes

Both pressure pouring and vacuum pouring are used with investment casting. Both processes speed the casting cycle and aid in filling out of fine detail. Centrifuging or spinning is also used in some cases but not as often as vacuum or pressure.

A variation on investment casting is being developed in England. This involves investment casting without expendable patterns, making use of ethyl silicate in the mold material. The mold material is prepared in the form of a slurry by mixing a suitably graded refractory filler with a colloidal suspension of silica in alcohol to which a reagent has been added to produce a carefully controlled gelling reaction. The mold is poured in two or more parts around matched sections of the master pattern. As the slurry gels, it passes through a tough rubbery stage, at which time it is removed from the master pattern, fired and assembled. This eliminates the need for making a pattern for each casting, as the master pattern is used again and again. Also the flexibility of the mold in the gel stage makes possible the use of one-piece patterns with some back draft. Though still in the developmental stages, it would seem that the process might offer some economic advantages for casting certain types of shapes in larger sizes.

Special Sand Castings

The Method

Though a sand casting is not normally regarded as a close tolerance cast form, several foundries have set up operations to cast in sand to a higher degree of accuracy than is normally expected with this process. The higher accuracy is attributable to foundry techniques and closer control over the variables rather than a change in process. Carefully constructed baked sand cores are used in areas where this accuracy is specified, while normal green sand molds are used elsewhere. This offers the obvious advantage of limiting the increased cost due to greater accuracy to those areas where it is necessary.

Materials and Properties

At present, most of this type of sand casting is being done in aluminum and magnesium alloys and the phosphor and tin bearing bronzes. However, the use of sand casting for close tolerance work is relatively new and its possibilities and limitations have not been fully explored. The as-cast mechanical properties of the castings are approximately the same as those found in conventional sand castings. They may be slightly higher due to the closer control exercised over all the foundry operations.

Close Tolerance Castings

Getting into Production (From completed design to production)	Size Range	Average Size of Competitive Casings, Lb.	Min. Sect. Thickness, in.	As-Cast Finish, Obtainable in Limited Areas, rms	Remarks
4-6 wks	Max. size not known. Present production runs from under 1 lb to parts 6 ft in length.	1-4	0.050	75-80	Relatively new refinements in techniques. Limitations not fully explored.
4-6 wks	½ to 800 lb	20-30	0.070	60	Process in infancy. Size only limited by size of mold making machine.
4-6 wks	Under 1 oz to over 100 lb	3 to 5	0.040-0.060	50	May be used in conjunction with sands and permanent molds.
6-12 wks	1 oz to 600 lb	1 to 10	0.090	100-125	Gray iron may be cast, but not with the same degree of accuracy.
8-14 wks	Under 1 oz to 75 lb in Al Under 1 oz to 200 lb in Zn	½ to 1	0.050	50	—
4-6 wks	Under 1 oz to 25 lb in wax or plastic and over 100 lb in frozen mercury	Up to 1	0.030	60 wax and plastic 40 mercury	Frozen mercury process is relatively new. Full possibilities have not been explored.

2. These figures are general for one set of equipment. Actual rate of casting production would depend on no. of cavities per mold.

Design Factors

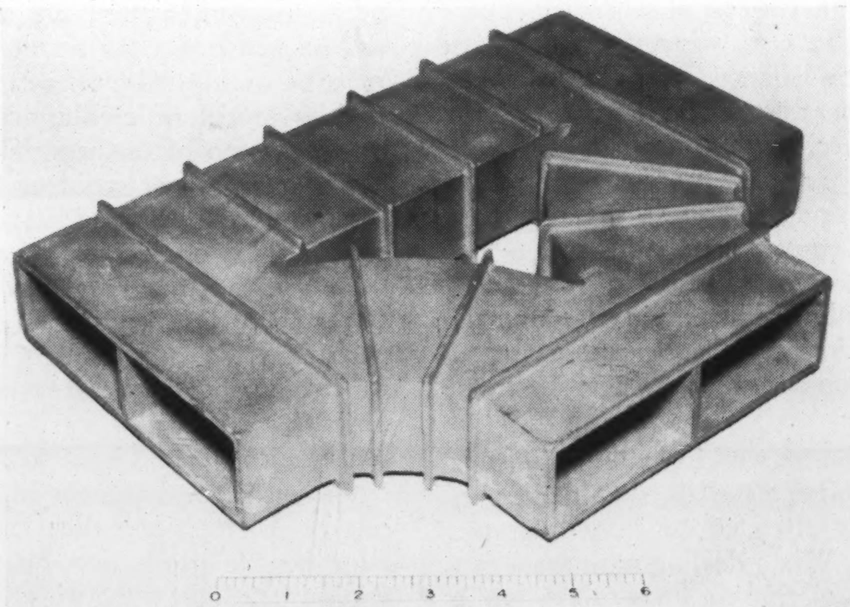
Tolerances — Since no applicable standards have been established in this field as yet, tolerances which have been held on commercial castings will indicate the degree of accuracy obtainable. On linear dimensions up to 1¼ in. ±0.003 in., up to 3 in. ±0.005 in., and up to 7 in. ±0.010 in. over-all tolerances have been held.

Size and Shape — Castings have been produced by this technique ranging in size from 1 in. to 6 ft in length. Since the high degree of accuracy requires the use of baked sand cores, it is difficult to say just what limits may be set for maximum practical size of accurate cores.

The limitations on complexity of shape are approximately the same as those for conventional sand castings. It should be pointed out again that the maximum accuracy must be on internal areas where the cores are located. The process is well suited to shapes such as electronic wave guides, where the exterior areas may not be critical, but a high degree of dimensional accuracy and surface smoothness is required on the interior areas.

Other Considerations — Holes as small as ½ in. in dia have been cored successfully and on small plane areas wall thicknesses of 0.050 have been held. The as-cast surface finish may range from 75 to 100 rms.

Case History



PART AND REQUIREMENT — Waveguide Component. Special sand casting in aluminum. The interior areas must have surface finish in the range of 75 to 100 rms. Tolerances on internal areas are held to ±0.003 in. on smaller, ±0.005 on larger dimensions. Right angles and corners must be maintained with radii in the range of 0.005 in.

ADVANTAGES OF CASTING—Part is cast in one piece. No machining is required on internal areas. Cost of holding accurate dimensions limited to those areas where accuracy is mandatory. Non-critical area formed by conventional sand mold.

Two Cardinal Rules for Close Tolerance Casting

1—NEVER SPECIFY TOLERANCES THAT ARE NOT ABSOLUTELY NECESSARY.

As one foundryman puts it, "The customer pays for all rejections". Any tolerance called out that is not necessary will waste your money. A closer tolerance will generally mean an increased cost.

2—ALWAYS CONSULT THE FOUNDRY WHEN DESIGNING THE CASTING.

Submitting a finished design to a foundry may well mean a revision of design. Each casting process has characteristics which should be incorporated in the design. By consulting the foundry first, the most economical design for that process can be worked out in the shortest possible time.

Some Cost Factors

The only practical way of determining what a close tolerance casting can do for you in reducing the cost of a product is to compare the end cost of the finished part. As was mentioned before, the cost of the casting process itself may often be more than the forming method used previously. However, many times this increased cost will be more than offset by a reduction in the cost of subsequent operations. In cases where these costs approach a balance the dividend resulting from a reduction in scrap loss can be a deciding factor. An ideal case might couple the economies of a high production operation with a reduction in subsequent machining and a low loss in scrap material to provide an outstanding reduction in over-all manufacturing cost. Under more typical conditions, the balance may be more delicate.

Engineers working with a difficult-to-machine materials should be particularly attracted to close tolerance casting. When dealing with these materials, machining may make up a large part of the total cost of producing a part, and a reduction in this operation will mean a substantial reduction in the end cost of a product.

Though in some cases, parts may be cast to such accuracy that subsequent finishing is negligible, this will not always be the case, and should not be expected. It will depend on the specifications of the part. As was mentioned before, casting cannot attain the accuracy obtainable with machining. However, in most cases, rough-cut machining can be elimianted, finishing operations reduced to a minimum.

Production

The economies of producing a part depend to a great extent on the production quantities and speed. The production rate figures given in the accompanying table are general and refer to the rate of filling one mold or die. Each of the processes discussed here can utilize multiple cavity dies or molds. When these are used, the rate at which a mold or die is filled must be multiplied by the number of cavities to determine the actual rate of production of castings. The number of cavities per mold or die will depend on the size and shape of the part. This is one of the reasons that these casting methods lend themselves well to the production of small parts. In some cases, the requirements for feeding certain shapes may also limit the number of cavities which can be incorporated in a mold or die.

Generally speaking, the higher the cost of the tools and dies, the larger must be the production quantity to minimize the cost per casting. Tooling costs for permanent mold and die casting fall in the high cost group, and these are usually justified by a relatively large production quantity. Tooling for shell molding is lower, and that for investment, plaster mold and sand casting is lower still, which generally corresponds to production requirements for these processes. In some cases the intrinsic characteristics of the design of the part is the governing factor, and immediate cost may be disregarded in favor of long range cost and practicality of production.

In some cases the design of a part cannot be "frozen" as it leaves the drawing board, but may require functional testing and modification. If such a part is to be produced by permanent mold or die casting where the tooling costs are high, it might be wise to utilize the flexibility of investment or plaster mold casting to produce pilot quantities for testing and development before going to the expense of manufacturing a production mold or die.

When using any of the six processes, it should be remembered that the resultant castings will be only as good as the tooling from which they are made. A good casting cannot be made from a poor mold or die. Where higher degrees of accuracy are required in the casting, higher degrees of accuracy are necessary in the original tooling. This costs money. There are areas on a great many parts where the normal accuracy of the process will suffice, and specifying a greater degree will only incur an unnecessary cost. By specifying accurately the critical dimensions and working out the design of the part with the foundryman, the use of a close tolerance casting can result in a substantial reduction in the manufacturing cost of a product.

Acknowledgments

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Alloys Precision Castings Co.
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Cooper Alloys Casting Co.
Eaton Manufacturing Co., Foundry Div.
Eclipse-Pioneer Div., Bendix Aviation Corp.
The Electric Auto-Lite Co., Die Casting Div.
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Materials Engineering File Facts

MATERIALS & METHODS
September • 1954
Number 283

New Standard Designations for Wrought Aluminum Alloys

New Designation	Old Designation	Chemical Composition Limits, % (max unless shown as a range)											Aluminum Min.
		Silicon	Iron	Copper	Manganese	Magnesium	Chromium	Nickel	Zinc	Titanium	Others Each	Others Total	
1030	AE1S	—	—	—	—	—	—	—	—	—	—	—	99.30
1050	AD1S	—	—	—	—	—	—	—	—	—	—	—	99.50
1060	BD1S	—	—	—	—	—	—	—	—	—	—	—	99.60
1070	AC1S	—	—	—	—	—	—	—	—	—	—	—	99.70
1075	JC1S	—	—	—	—	—	—	—	—	—	—	—	99.75
1080	BC1S	—	—	—	—	—	—	—	—	—	—	—	99.80
1085	AB1S	—	—	—	—	—	—	—	—	—	—	—	99.85
1090	FB1S	—	—	—	—	—	—	—	—	—	—	—	99.90
1095	AA1S	—	—	—	—	—	—	—	—	—	—	—	99.95
1099	BA1S	—	—	—	—	—	—	—	—	—	—	—	99.99
1100	2S	1.0 Si + Fe		0.20	0.05	—	—	—	0.10	—	0.05	0.15	99.00
1130(1)	R-308(1)	0.7 Si + Fe		0.20	—	—	—	—	—	—	0.05	0.15	99.30
1145(2)	BE1S	0.55 Si + Fe		0.05	0.05	—	—	—	—	—	0.03	—	99.45
1160	CD1S, 99.6	0.40 Si + Fe		0.05	—	—	—	—	—	—	0.05	0.15	99.60
1175(4)	99.75	0.15 Si + Fe		0.10	—	—	—	—	—	—	0.02	—	99.75
1180(5)	CC1S, R998	0.09	0.10	0.03	—	—	—	—	—	—	0.02	—	99.80
1187(5)	EB1S, 99.87	0.06	0.06	—	—	—	—	—	—	—	0.01	—	99.87
1197(5)	CA1S	0.006	0.006	0.006	—	0.006	—	—	0.006	—	0.002	0.01	99.97
1230(6)	99.3	0.7 Si + Fe		0.10	0.05	—	—	—	0.10	—	0.05	0.15	99.30
1235(2)	R995	0.65 Si + Fe		0.05	—	—	—	—	—	—	0.05	0.15	99.35
2011	11S	0.40	0.7	5.0–6.0	—	—	—	—	0.30	—	0.05(7)	0.15	Rem
2014	14S, R301 Core	0.50–1.2	1.0	3.9–5.0	0.40–1.2	0.20–0.8	0.10	—	0.25	0.15	0.05	0.15	Rem
2017	17S	0.8	1.0	3.5–4.5	0.40–1.0	0.20–0.8	0.10	—	0.25	—	0.05	0.15	Rem
2018	18S	0.9	1.0	3.5–4.5	0.20	0.45–0.9	0.10	1.7–2.3	0.25	—	0.05	0.15	Rem
2024	24S	0.50	0.50	3.8–4.9	0.30–0.9	1.2–1.8	0.10	—	0.25	—	0.05	0.15	Rem
2025	25S	0.50–1.2	1.0	3.9–5.0	0.40–1.2	0.05	0.10	—	0.25	0.15	0.05	0.15	Rem
2117	A17S	0.8	1.0	2.2–3.0	0.20	0.20–0.50	0.10	—	0.25	—	0.05	0.15	Rem
X2214	XB14S	0.50–1.2	0.25	3.9–5.0	0.40–1.2	0.20–0.8	0.10	—	0.25	0.15	0.05	0.15	Rem
2218	B18S	0.9	1.0	3.5–4.5	0.20	1.2–1.8	0.10	1.7–2.3	0.25	—	0.05	0.15	Rem
2225	B25S	0.50–1.2	0.30	3.9–5.0	0.40–1.2	0.05	0.10	—	0.25	0.15	0.05	0.15	Rem
X2316	Xc16S	—	—	—	—	—	—	—	—	—	—	—	—
2618	F18S	—	—	—	—	—	—	—	—	—	—	—	—
3003	3S	0.6	0.7	0.20	1.0–1.5	—	—	—	0.10	—	0.05	0.15	Rem
3004	4S	0.30	0.7	0.20	1.0–1.5	0.8–1.3	—	—	0.10	—	0.05	0.15	Rem
X3005	XA5S	—	—	—	—	—	—	—	—	—	—	—	—
4032	32S	11.0–13.5	1.0	0.50–1.3	—	0.8–1.3	0.10	0.50–1.3	0.25	—	0.05	0.15	Rem
4043	43S, K145	4.5–6.0	0.8	0.30	0.05	0.05	—	—	0.10	0.20	0.05	0.15	Rem
4045	45S	9.0–11.0	0.8	0.30	0.05	0.05	—	—	0.10	0.20	0.05	0.15	Rem
4343	C43S, 44S, K143	6.8–8.2	0.8	0.25	0.10	—	—	—	0.20	—	0.05	0.15	Rem
X4543	XE43S	—	—	—	—	—	—	—	—	—	—	—	—
5005	A50S, R305, K155	0.40	0.7	0.20	0.20	0.50–1.1	0.10	—	0.25	—	0.05	0.15	Rem
5050	50S	0.40	0.7	0.20	0.10	1.0–1.8	0.10	—	0.25	—	0.05	0.15	Rem
5052	52S	0.45 Si + Fe		0.10	0.10	2.2–2.8	0.15–0.35	—	0.20	—	0.05	0.15	Rem
X5055	X55S	0.30	0.7	0.25	0.30–0.80	4.0–5.0	0.25	—	0.25	—	0.05	0.15	Rem
5056	56S	0.30	0.40	0.10	0.05–0.20	4.5–5.6	0.05–0.20	—	0.10	—	0.05	0.15	Rem
5083	LK183	0.40	0.40	0.10	0.50–1.0	4.0–4.9	0.25	—	0.25	0.15	0.05	0.15	Rem
5086	K186	0.40	0.50	0.10	0.20–0.7	3.5–4.5	0.25	—	0.25	—	0.05	0.15	Rem
5154	A54S	0.45 Si + Fe		0.10	0.10	3.1–3.9	0.15–0.35	—	0.20	0.20	0.05	0.15	Rem
5254	B54S	0.45 Si + Fe		0.05	0.01	3.1–3.9	0.15–0.35	—	0.20	0.05	0.05	0.15	Rem
X5356	XC56S	0.50 Si + Fe		0.10	0.05–0.20	4.5–5.5	0.05–0.20	—	0.10	0.06–0.20	0.05(8)	0.15	Rem
5357	C57S, K157	0.12	0.17	0.07	0.15–0.45	0.8–1.2	—	—	—	—	0.05	0.15	Rem
X5405	XD50S	—	—	—	—	—	—	—	—	—	—	—	—
5652	F52S	0.40 Si + Fe		0.05	0.01	2.2–2.8	0.15–0.35	—	0.10	—	0.05	0.15	Rem
6003(12)	R306, K162	0.35–1.0	0.6	0.10	0.8	0.8–1.5	0.35	—	0.20	0.10	0.05	0.15	Rem
6053	53S	(9)	0.35	0.10	—	1.1–1.4	0.15–0.35	—	0.10	—	0.05	0.15	Rem
6061	61S	0.40–0.8	0.7	0.15–0.40	0.15	0.8–1.2	0.15–0.35	—	0.25	0.15	0.05	0.15	Rem
6062	62S	0.40–0.8	0.7	0.15–0.40	0.15	0.8–1.2	0.04–0.14	—	0.25	0.15	0.05	0.15	Rem
6063	63S	0.20–0.6	0.35	0.10	0.10	0.45–0.9	0.10	—	0.10	0.10	0.05	0.15	Rem
6066	66S	—	—	—	—	—	—	—	—	—	—	—	—
6151	A51S	0.6–1.2	1.0	0.35	0.20	0.45–0.8	0.15–0.35	—	0.25	0.15	0.05	0.15	Rem
X6251	XB51S	—	—	—	—	—	—	—	—	—	—	—	—
6253	B53S	(9)	0.50	0.10	—	1.0–1.5	0.15–0.35	—	1.6–2.4	—	0.05	0.15	Rem
X6453	XD53S	—	—	—	—	—	—	—	—	—	—	—	—
6553	E53S	—	—	—	—	—	—	—	—	—	—	—	—
6951	J51S, K160	0.20–0.50	0.8	0.15–0.40	0.10	0.40–0.8	—	—	0.20	—	0.05	0.15	Rem
7070	70S	—	—	—	—	—	—	—	—	—	—	—	—
7072	72S	0.7 Si + Fe		0.10	0.10	0.10	—	—	0.8–1.3	—	0.05	0.15	Rem
7075	75S	0.50	0.7	1.2–2.0	0.30	2.1–2.9	0.18–0.40	—	5.1–6.1	0.20	0.05	0.15	Rem
X7178	XA78S	0.50	0.7	1.6–2.4	0.30	2.4–3.1	0.18–0.40	—	6.3–7.3	0.20	0.05	0.15	Rem
7277	B77S	0.50	0.7	0.8–1.7	—	1.7–2.3	0.18–0.35	—	3.7–4.3	0.10	0.05	0.15	Rem
8099	R399	—	—	—	—	—	—	—	—	—	—	—	98.7
8112	K112	1.0	1.0	0.40	0.6	0.7	0.20	—	1.0	—	0.05	0.15	Rem
X8280	XB80S	—	—	—	—	—	—	—	—	—	—	—	—
EC(10)	EC	—	—	—	—	—	—	—	—	—	—	—	99.45

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(2) Foil.
(3) Tubular conductors.
(4) Cladding on No. 2 Reflector sheet.
(5) Electrolytic condenser foil.
(6) Cladding on Alclad 2024.
(7) Also contains 0.20 to 0.6 per cent each of lead and bismuth.
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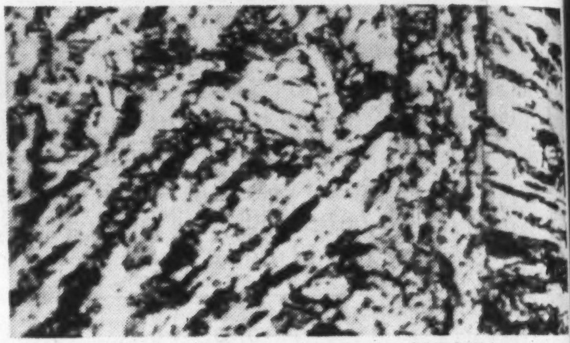
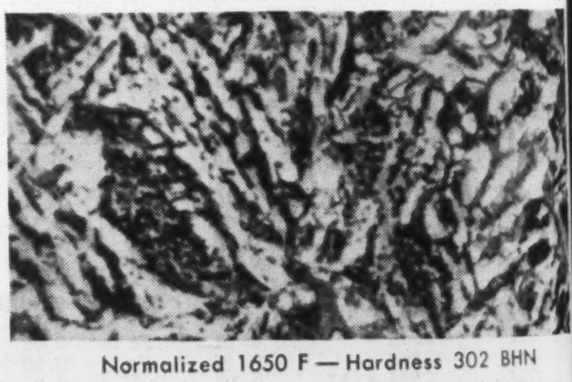
TYPICAL THROUGH-HARDENING GRADES

1340 2340 3140
4042 4140 4340
4640 5140 8640
8740 9440

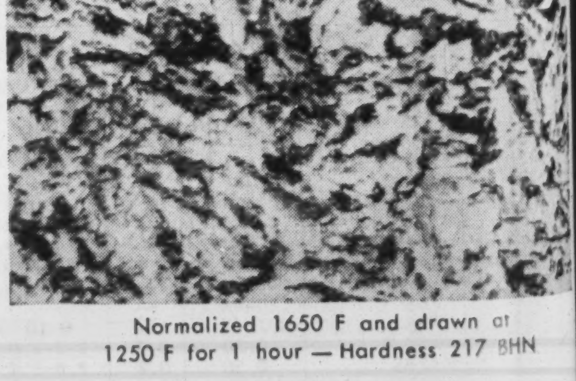
Typical Microstructures (at 1000 X) and Hardnesses, 4140 Steel



Hot Rolled — Hardness 285 BHN



Normalized 1650 F — Hardness 302 BHN



Normalized 1650 F and drawn at 1250 F for 1 hour — Hardness 217 BHN

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Materials Engineering File Facts

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September • 1954
Number 284

Aluminum and Aluminum Alloy Temper Designation System

The standard temper designation system for aluminum and aluminum alloys consists of a letter indicating the basic temper, which, except for the annealed and as-fabricated tempers, is more specifically defined by the addition of one or more digits.

There are four basic tempers, namely, "O"—annealed, "F"—as fabricated, "H"—strain hardened, and "T"—heat treated. The letter "W" is used to designate the unstable condition following solution heat treatment, and if time subsequent to heat treatment is indicated, may also be considered a basic temper.

The system is summarized in the following explanatory notes and examples. Examples given here cover only wrought alloys, although the system covers castings as well as wrought products. It is a principle of this system that a change in a temper designation is made only when some variation in the same basic operations alters significantly the characteristics of the product.

Symbol	Condition	Explanation
-F	As Fabricated	Applies to products which are supplied in the condition resulting from normal manufacturing operations without imposing special practices to control the amount of strain hardening or thermal treatment. For wrought products, there is no guarantee of mechanical properties.
-O	Annealed, recrystallized	Applies to the softest temper of wrought alloy products.
-H	Strain hardened	Applies to those products which are not subjected to thermal treatments to increase their mechanical properties, but which have their strength increased by strain hardening with or without supplementary thermal treatment to produce partial softening. The -H is always followed by two or more digits. The first digit indicates the specific combination of basic operations and the following digit or digits the final degree of strain hardening, as explained below.
Subdivisions	**of the -H Temper**	
-H1	Strained hardened only	As indicated above, the second digit designates the amount of cold work performed. The digit 8 has been selected to represent the hardest commercially practical temper, written thus: -H18. Since -H18 is considered full hard, and -0 is annealed, material with tensile strength halfway between soft and full hard, or half hard, is designated -H14, quarter hard -H12, and so on. A third digit is often used to identify a special set of properties, for example, -H141 may represent material in some alloy with the same minimum properties as -H14, but with maximum values that are closer than standard. Or, it may represent material in some alloy with minimum values slightly different from those of -H14, but not sufficiently different to place it in the -H13 or -H15 classification. Extra hard tempers are designated by use of the second digit 9, with or without a third digit.
-H2	Strain hardened and partially annealed	It is often desirable to obtain a certain strength range in the strain hardened alloys by working to a harder temper and then reducing the strength to the desired level by partial annealing. This process is identified by the figure 2 in the first digit place, and the residual amount of cold work is then designated by the same method employed for the -H1 series. Thus, -H28 is full hard, -H24 half hard, and so on.
-H3	Strain hardened and stabilized	The properties of magnesium-containing alloys in the strain hardened condition are stabilized by a low temperature heating, thus lowering slightly their strength and increasing ductility. If the treatment is not employed, the change of properties occurs over a long time at room temperature. Use of this treatment is indicated by the digit 3 in the first digit place, and the degree of strain hardening is indicated in the usual way by one or two following digits.
-W	Unstable condition following solution heat treatment	This designation, because of natural aging, is specific only when the period of aging is indicated, e. g., 24S-W(½ hr); 75S-W(2 mo).
-T	Treated to produce stable tempers other than -F, -O, or -H	Applies to products thermally treated to produce stable tempers with or without supplementary strain hardening. The -T followed by the numerals 2 to 19, inclusive, designates one specific combination of basic operations, thus 61S-T6. Should some other variation of the same basic operations be applied to the same alloy, resulting in different characteristics, then other digits are added to the basic designation (61S-T61 or 61S-T62). It should be understood that a period of natural aging at room temperature may occur between or after the operations listed. Control of this period is exercised when it is metallurgically important, but is not indicated by the designation.
Subdivisions	**of the -T Temper**	
-T2	Annealed (Castings only)	Applies to castings only, for improving ductility and increasing dimensional stability.
-T3	Solution heat treated and cold worked, naturally aged to substantially stable temper	Applies to those products where cold work is performed for the primary purpose of improving the strength, thus, 24S-T36, and also applies to those products in which the effect of cold work, such as flattening or straightening, is recognized in applicable specifications (24S flat sheet heat treated by the supplier is designated 24S-T3). No control is exercised to cold work at any particular stage during the natural aging cycle.
-T4	Solution heat treated and naturally aged to a substantially stable condition	Applies when the product is not cold worked after heat treatment (24S sheet heat treated by customer becomes 24S-T4), and also when applicable specifications do not recognize the effect of cold work resulting from flattening and straightening operations. (61S flat sheet heat treated by the supplier is designated 61S-T4). The alloy 75S does not have a commercial -T4 designation.
-T5	Artificially aged only	Applies to products which are artificially aged without prior solution heat treatment. The artificial aging of these products improves mechanical properties (63S-T5 extrusions), and dimensional stability (for castings).
-T6	Solution heat treated and artificially aged	Applies to products which are not cold worked after solution heat treatment, or in which the effect, if any, of flattening or straightening is not recognized in applicable specifications. (Whether flattened or not, 61S heat treated and aged is designated 61S-T6, and 75S, treated in the same manner, is 75S-T6).
-T7	Solution heat treated and stabilized	Applies to products in which the temperature and time conditions for stabilizing are such that the alloy is carried beyond the point of maximum hardness, providing control of growth and/or residual stress (18S-T71, 32S-T72).
-T8	Solution heat treated, cold worked and artificially aged	Applies when the cold working is done for the purpose of improving strength (11S-T8, Alclad 24S-T86), and also when the cold working effect of flattening or straightening is recognized in applicable specifications (Alclad 24S-T81 flat sheet).
-T9	Solution heat treated, artificially aged and cold worked	61S wire heat treated, artificially aged, and cold worked is 61S-T91.
-T10	Artificially and cold worked	Applies today only to castings. May find application in the future to wrought alloys, as well.

Courtesy of The Aluminum Association

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Materials Engineering File Facts

MATERIALS & METHODS
September • 1954
Number 285

Materials Data Sheet

Styrene Plastics

Styrene Plastics are thermoplastics made from styrene monomer as the principal ingredient. In the older group of commercial materials, the polystyrenes, the styrene monomer is generally polymerized alone and 95% or more of the mass is derived from this source. For some applications, the polystyrenes are not suitable and a second group, the modified styrene plastics, was developed to extend the range of usefulness of these materials. In the modified styrene plastics, 50% or more of the mass is derived from the styrene monomer, the balance from other monomers, copolymers or other modifiers. The modified styrenes are very numerous, each being superior in certain properties but attaining this superiority at the expense of other properties.

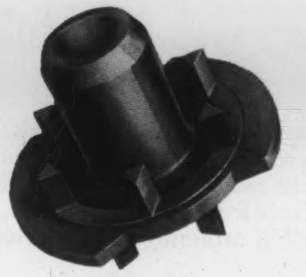
Type	ASTM Test Method	Polystyrenes			Modified Styrenes	
		General Purpose Type 1	Lubricated Type 2	Improved Heat Resistance, Type 3	Heat and Chemical Resistance	Shock Resistant
PHYSICAL PROPERTIES						
Specific Gravity	D792	1.05–1.08	1.05–1.08	1.05–1.08	1.05–1.11	0.98–1.10
Thermal Cond, Btu/Hr/Sq Ft/Ft/°F	C177	0.58–0.80	0.58–0.80	0.58–0.80	0.46–0.73	0.24–0.73
Coeff of Exp per °F	D696	$3.3–4.4 \times 10^{-5}$	$3.3–4.4 \times 10^{-5}$	$3.3–4.4 \times 10^{-5}$	3.8×10^{-5}	$1.9–11.7 \times 10^{-5}$
Spec Ht, Btu/Lb/°F	—	0.32–0.35[a]	0.32–0.35[a]	0.32–0.35[a]	0.32–0.35[a]	0.30–0.35[a]
Water Absorption, 24 hr, %	D570	0.04–0.05	0.04–0.06	0.04–0.05	0.05–0.40	0.15–0.55
MECHANICAL PROPERTIES						
Mod of Elasticity in Tension, Psi	D638	$4.0–5.0 \times 10^{5}$	$4.0–5.0 \times 10^{5}$	$4.0–6.0 \times 10^{5}$	$4.0–6.0 \times 10^{5}$	$1.8–4.0 \times 10^{5}$
Tensile Str, Psi	D638	5,000–9,000	5,500–7,500	7,000–9,500	7,000–12,000	3,500–7,000
Hardness, Rockwell	D785	M70–M80	M65–M80	M70–M80	M65–M90	M20–M40
Impact Str Izod Notched (ft-lb per in. of notch)	D256	0.25–0.40	0.25–0.40	0.25–0.40	0.25–0.50	0.5–11.0
Mod of Elasticity in Flexure, Psi	D790	$4.0–5.0 \times 10^{5}$	$4.0–5.0 \times 10^{5}$	$4.0–6.0 \times 10^{5}$	$4.0–6.0 \times 10^{5}$	$1.5–4.0 \times 10^{5}$
Flexural Str, Psi	D790	8,000–15,000	8,500–12,000	10,000–15,000	10,000–17,000	—
Compressive Yld Str, Psi (Upper)	D695	11,500–16,000	11,500–16,000	11,500–16,000	11,500–16,000	4,800–9,000
ELECTRICAL PROPERTIES						
Elect Res, Ohm-Cm (Volume)	D257	$10^{17}–10^{19}$	$10^{17}–10^{19}$	$10^{17}–10^{19}$	$10^{13}–10^{17}$	$10^{12}–10^{17}$
Dielectric Str (Short Time) Volts/mil	D149	500–700	500–650	500–750	400–600	300–600
Dielectric Constant						
60 Cycles	D150	2.45–2.65	2.45–2.65	2.45–2.65	2.45–3.4	2.45–4.75
1,000,000 Cycles	D150	2.45–2.65	2.45–2.65	2.45–2.65	2.45–3.1	2.45–3.8
Loss Factor						
60 Cycles	D150	$25–80 \times 10^{-5}$	$25–135 \times 10^{-5}$	$25–80 \times 10^{-5}$	$0.25–34 \times 10^{-3}$	$0.1–0.7 \times 10^{-3}$
1,000,000 Cycles	D150	$25–100 \times 10^{-5}$	$25–135 \times 10^{-5}$	$25–100 \times 10^{-5}$	$0.25–40 \times 10^{-3}$	$0.14–1.0 \times 10^{-3}$
FABRICATING PROPERTIES						
Compression Ratio (Bulk Factor)	D1182	1.6–2.3	1.6–2.3	1.6–2.3	1.6–2.4	1.6–2.4
Compression Molding Temp, F	—	265–350	250–350	275–400	300–400	250–325
Compression Molding Pressure, Psi	—	1,000–10,000	1,000–5,000	1,000–10,000	1,000–5,000	1,000–8,000
Injection Molding Temp, F	—	325–550	300–500	400–650	350–700	375–600
Injection Molding Pressure, Psi	—	10,000–30,000	7,500–25,000	10,000–30,000	10,000–33,000	6,000–30,000
Extruding Temp, F	—	375–500	300–500	400–550	450–550	340–500
MAX RECOMMENDED SERVICE, TEMP F	—	150–175[b]	135–170[b]	170–180[b]	170–200[b]	140–175[b]
CORROSION RESISTANCE		Good resistance to alkalies, salts, lower alcohols, glycols, water; fair resistance to mineral and vegetable oils; soluble in aromatic and chlorinated hydrocarbons; softened or attacked by higher alcohols, gasoline, strong oxidizing acids, chlorine and bromine waters.			Improved resistance to attack by solvents, oils and other organic liquids over polystyrenes without decreased resistance to inorganic materials.	Similar to polystyrenes.
USES		Electrical parts including storage battery cases; insulators, coil forms; industrial parts including fluorescent light fixtures, rigid containers, instrument panels, light machine housings, name-plates; refrigerator parts; housewares, toys.			Battery cases, coil forms, drafting instruments, sight glasses on pressure lubricating systems, thermostat housings.	Pipe and fittings, large area refrigerator parts, containers.

[a] *For crystal material.*

[b] *Actual continuous service limit depends on applied stress, shape of part and molding details.*

Prepared with the Assistance of the Manufacturing Chemist's Association, Inc.
Based on the Chemist's Association Publication "Technical Data on Plastics", 1952.

difficult made easy



This part is cast complete except for a light reaming operation. It is strong, accurate and costs considerably less than if fully machined.

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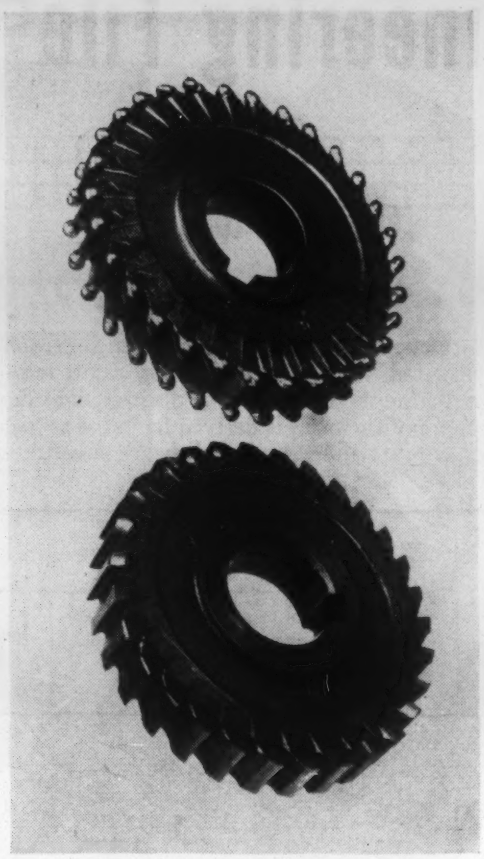
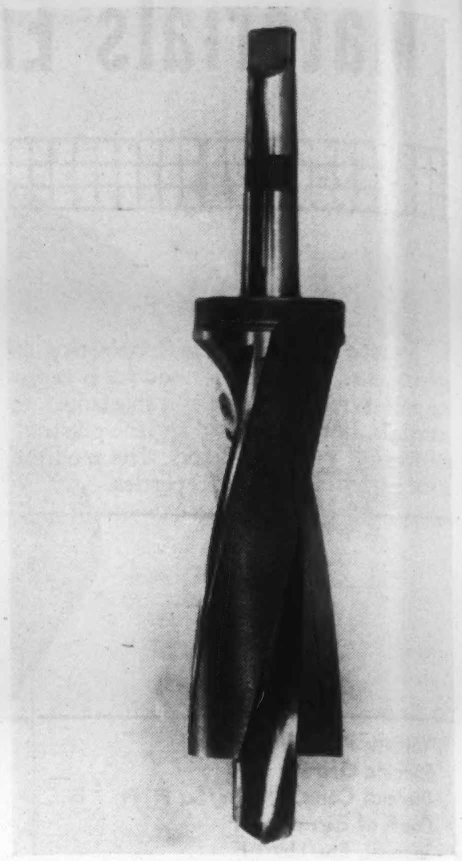


These milling cutters were saved by rebuilding and regrinding corners (top) and regrinding to new contour (bottom).



Because of being built with only two lands, this large drill cut inaccurately until rebuilt by welding (see right).

Arc Weld Repairs on High Speed Tool Steel

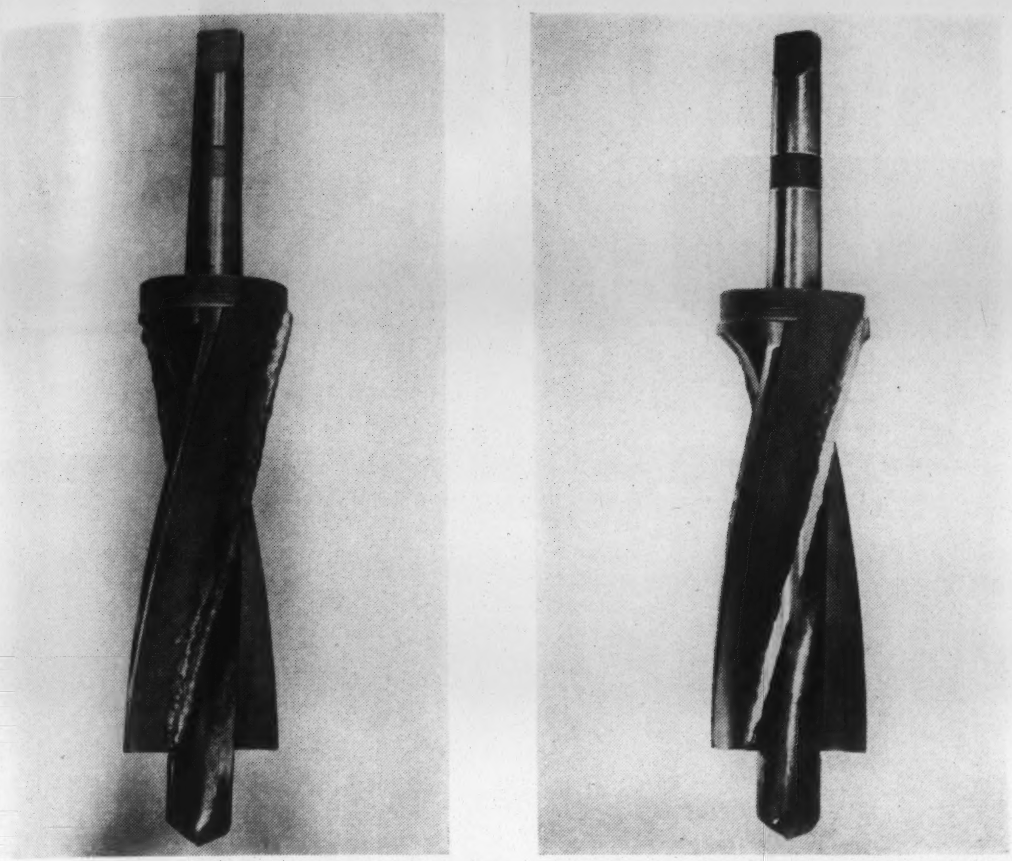
by **KENNETH ROSE**, **Mid-Western Editor, Materials & Methods**

Inert-gas-shielded arc welding used to rebuild and alter cutting tools extends their service life.

● HIGH SPEED STEEL TOOLS are expensive and frequently difficult to procure. A considerable quantity of these expensive tools was being scrapped at Buick Div. General Motors Corp., because of excessive wear, breakage of a part of a cutting edge, or because of obsolescence. To reduce this loss, research metallurgists at the company introduced a method for arc welding the tools with a high-speed steel rod so that broken or worn edges could be built up, ground to shape, and the piece returned to service.

The process uses an inert-gas-shielded arc, with argon gas as the protective blanket and alternating current with superimposed high frequency to stabilize the arc. The high frequency eliminates spatter or wandering of the arc; it pin-points the arc to the small area where it is required, and thus avoids damage of surfaces finished to size. Conventional equipment is used with tungsten electrode and a wire of M36 analysis for filler metal. The M36 wire is used with all grades of high speed steel. Its percent composition is:

Carbon	0.80 to 0.90
Chromium	3.75 to 4.25
Vanadium	1.25 to 2.25
Molybdenum	3.75 to 5.50
Tungsten	5.25 to 6.00
Cobalt	7.50 min.
Manganese	0.20 to 0.40



Two extra lands are welded on drill (left) and ground (right). These lands serve as guides and make for more accurate cutting.

The amperage used is in the low range of the machine, and is usually less than 40 amp because of the small weld area. To prepare the work for arc weld repairs, the broken area is ground out in the case of broken teeth on cutters. It is then Magnaflux inspected to insure removal of all cracks. The piece is then preheated to about 500 F. Higher temperatures would cause oxidation of the steel. The proper areas are then built up with the arc in the usual way, the repaired tool is given a draw at 1050 F, and is reground to size and contour.

With the stabilized arc repair, the buildup can be closely concentrated at the desired areas. Repairs formerly were attempted with oxyacetylene torch, but the area of the workpiece affected by the heat was large enough to make the method unsatisfactory.

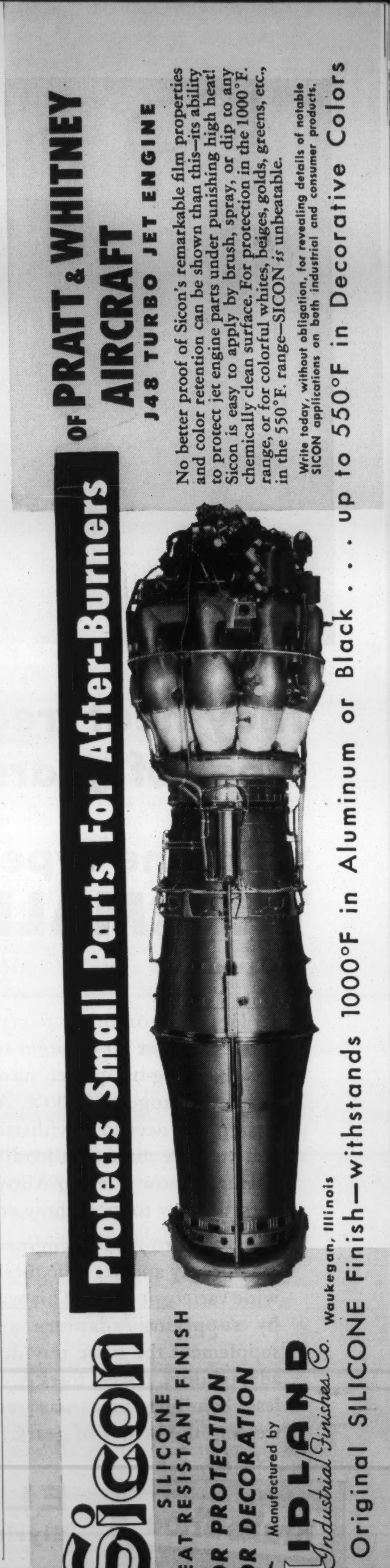
Typical of the repairs made by this method was that of a high speed steel broach. One of the teeth had been deeply broken out, making the tool unfit for service, but the piece was otherwise in good condition. After grinding out the broken metal, the area of the broken tooth was built up slightly above the level of the sound teeth. The built-up metal was then contoured by grinding, the restored tooth was sharpened, and the piece was returned to service.

In another case, a milling cutter had been resharpened frequently and was in serviceable condition, but wear along the sides of the teeth threatened to shorten its useful life. After the worn sides were built up with weld metal and reground to size, the cutter was ready for continued service. On single point tools, it had frequently been necessary to grind back the cutting edge as much as half an inch to square the edge. Such worn tools are now built up with weld metal, saving the grinding away of much valuable material.

Not all of the applications of the process are in the salvage of broken or worn tools. Frequently tools that are in perfect condition must be scrapped because of a change of design. Where the tool can be reshaped by grinding the reclamation of the piece is simple, but designs that required additional metal at some area to meet the new contour have heretofore meant the scrapping of the tool in most cases. With the arc deposition method it is now frequently possible to build up the profile to meet requirements.

Typical of redesign involving added metal was the treatment of a large drill, about 3 in. in dia. This cutting tool had been built with only two lands, and tended to cut inaccurately. Two additional lands were built up at right angles to the existing lands, and these served to steady the drill and give satisfactory performance.

For more information, Circle No. 407 ➤



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Thermalloy tray and fixtures with adapter in place to give different loading pattern. Spacers at right.

They heat treat 50 different types of gears . . .

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A large automotive parts manufacturer processes over 50 different types of gears in a carburizing-oil quench furnace where temperatures range to 1700°F. A heat-treat tray design was needed to withstand rugged service...to give maximum loading for all gears.

Here's how Electro-Alloys developed a versatile tray to meet these conditions:

First: Electro-Alloys engineers designed a type of tray and set of fixtures to handle this wide variety of gears. This was accomplished by supplying adapters and spacers to supplement the basic tray design. With this adaptability, fewer trays were needed . . . less handling time was required in heat treating the variety of gears.

Second: Trays, fixtures, adapters, spacers . . . all were cast in Thermalloy . . . a tough heat-resistant alloy developed specifically to take heavy loads and rough usage . . . to withstand elevated temperatures up to 2100°F. without scaling or cracking. This tray takes loads up to 315 lbs. per tray . . . has been in service for over 13 months.

Electro-Alloys has helped engineer many types of heat-treat parts and has cast them in Thermalloy for longer life. Why not put this knowledge to work for you . . . call your nearest Electro-Alloys office or write Electro-Alloys Division, 5001 Taylor Street, Elyria, Ohio, for a copy of Thermalloy Tray & Fixture Bulletin T-227.

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New Materials, Parts and Finishes

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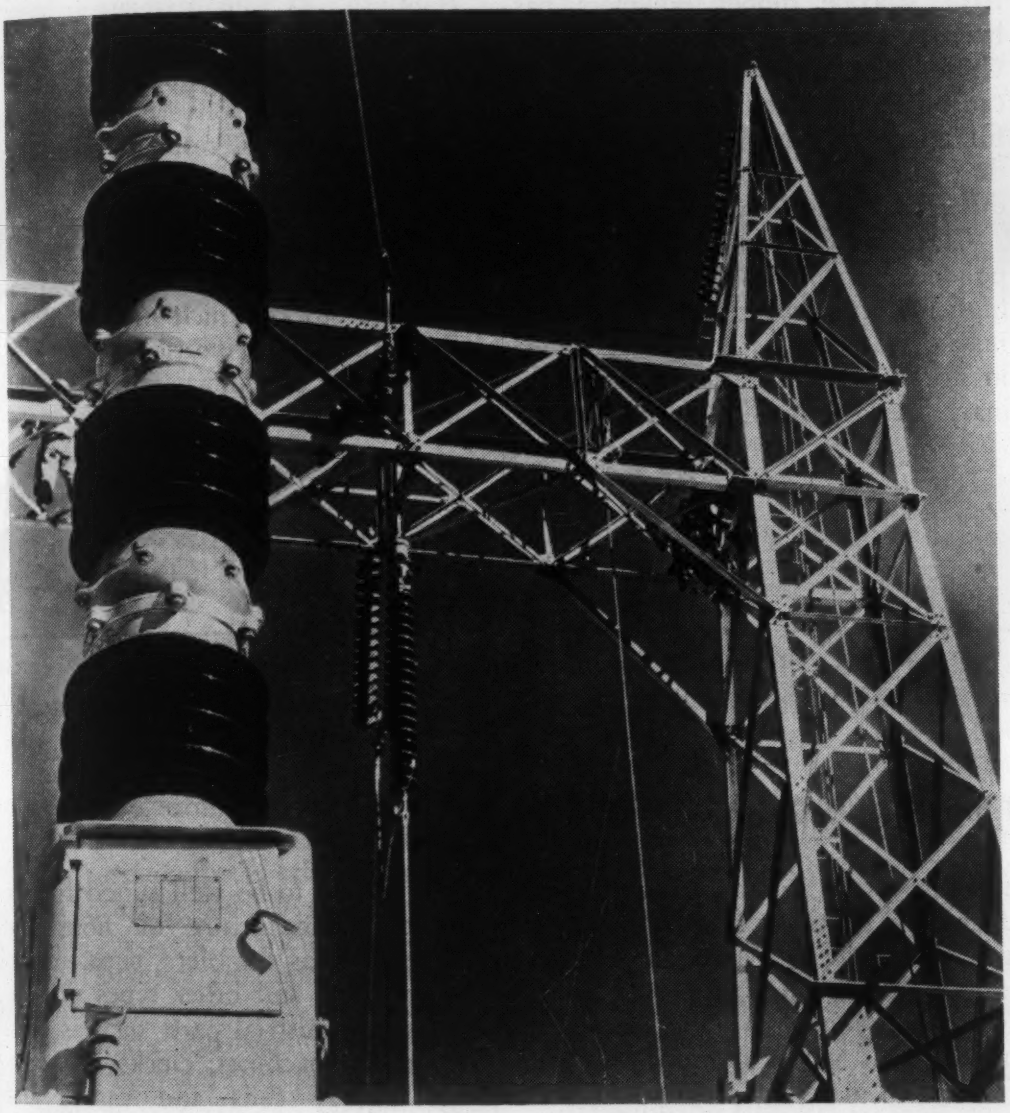


This power line tower is one type of structural application for which the new alloy is expected to find economical use.

New Non-Heat-Treatable Aluminum Alloy

Has—

- High Strength
- Good Weldability

Developed to meet the need for a high strength, common alloy for use in welded assemblies, K186 alloy is said to extend the use of aluminum to applications where heat-treatable alloys have been too costly in the past. Nominal composition of the alloy is 4.0 magnesium, 0.45 manganese, and 0.10% chromium.

Developed by the *Kaiser Aluminum & Chemical Corp.*, 1924 Broadway, Oakland 12, Calif., the alloy is recommended for use in applications such as unfired pressure vessels, structural towers, welded boat hulls, rocket motor tubing, guided missile containers, trusses and girders, truck and trailer frames, tanks and piplines.

Mechanical Properties

Typical mechanical properties of the alloy in various tempers are: tensile strength, in lb per sq in., ranges from 38,000 in 0 condition, 39,000 in H112 temper, to 47,000 in the H34 temper. Yield strength runs 17,000 in 0 condition, 19,000 in H112 temper and 37,000 in H34 temper. Typical elongation values, in per cent in 2 in., are 22 in the 0 condition, 14 in the H112 and 10 in the H34 temper.

The alloy is available in sheet and plate form in a full range of tempers. Developmental work is now in process on extrusion operations to extend the range of applications. Minimum mechanical properties for plate in H112 temper are 34,000 psi tensile strength, 14,000 psi yield strength, and elongation of 8%.

Formability of the alloy is said to be as good as that of 52S, as determined by tests including hammered, guided, impact and elevated temperature bend tests. Cold forming in H112 temper is good, and a high degree of formability is claimed when the material is heated to 400 F.

According to the company, accelerated and long term corrosion tests have indicated high corrosion resistance for the alloy. Standard finishing procedures may be used and corrosion resistant anodized finishes can be applied.

Weldability

Inert-gas-shielded arc welds were made transversely on 0.250 gage K186 hot-rolled plate with 56S filler wire using a square butt joint and two passes. Average results of 10 tensile tests made in the longitudinal direction of the plate showed joint efficiency with weld beads on was 89% and with beads machined flush, 79%. Longitudinal ultimate tensile strength of the parent metal was 44,700 psi. With beads on, ultimate across the weld was 39,900 psi and with beads machined flush, 35,500 psi.

Silicone Rubber Polymer Commercially Available

The newly released polymer is a clear material of extremely high viscosity.

Dow Corning 400 Gum, one of the basic silicone rubber polymers has been marketed by *Dow Corning Corp.,* Midland, Mich. The polymer can be compounded with a variety of fillers and vulcanizing agents to produce silicone rubbers suitable for different applications.

Clear, uniform and non-toxic the polymer is a dimethyl silicone gum of high molecular weight and extremely high viscosity. It is said to be stable in storage and to require no preliminary breakdown. Williams plasticity is 45 mils; specific gravity at 75 F is 0.98.

Heating a blend of Dow Corning 400 and certain organic peroxide vulcanizing agents converts the mixture to a cross-linked, resilient mass. The selection of inorganic fillers and additives determines to a large extent the physical properties of the finished elastomer. Careful compounding can produce stocks which meet AMS or SAE-ASTM specifications or the requirements of military wire and cable insulation.

New Molding Plastics Give Higher Properties, Production Advantages

Three new plastic molding materials offering improvements in moldability, curing speed and general properties have been marketed by the *Bakelite Co.,* a division of *Union Carbide and Carbon Corp.,* 260 Madison Ave., New York 16. A new styrene plastic is said to have higher plasticity with faster set-up, an acrylonitrile-styrene has greater toughness and chemical resistance, and a general purpose, brown phenolic is said to be particularly suited to electrical use.

Styrene

General purpose Bakelite SMD-3500 resin is said to offer production advantages by a combination of higher plasticity which allows easier flowing, and shorter set time which may reduce cycle time and speed part production. Other properties are said to be comparable to those of conventional polystyrenes.

The higher plasticity allows the molder to fill more cavities and mold larger pieces using the same cycle time and pressure. The material flows easily through pinpoint gates and dispersion nozzles, and will produce parts relatively free from strains and weld lines. Although the set time is in the range of most general purpose styrenes, in field tests the material has set up as much as 25% faster than materials previously used, according to claims made by the Bakelite Company.

Acrylonitrile Styrene

Bakelite C-11 molding material RMD-4001 is said to possess improved moldability, high clarity and good flow properties and set-up time. The material can be molded to close tolerances in thick and thin sections and can be turned, sawed, milled, drilled and tapped.

According to the company, the tensile strength of the material averages around 11,700 psi and in flexural strength, 15,700 psi. It is dimensionally stable through a temperature range of 40 to 190 F, has a low moisture absorption, and is resistant to mineral acids, alkalies, higher alcohols, gasoline, motor oils and vegetable, fruit and other food oils and acids.

It is said to be well suited for use in the manufacture of household items such as tumblers, cups, refrigerator pans and other types of containers; industrial parts such as parts for office machines, clocks and storage battery cells and cases; and novelties such as toys and pens.

Brown Phenolic

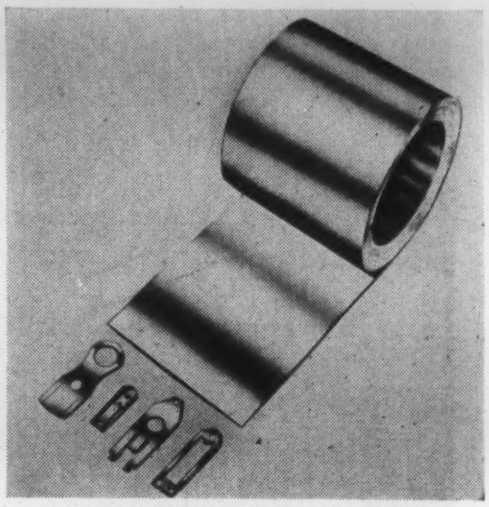
BMG-5000 Brown 15 phenolic molding material is said to possess all the properties of the black compound except in specific gravity. These properties include a wide molding latitude and a fast cure time permitting molding by compression, transfer and plunger methods. High rigidity at molding temperatures and at hot discharge from the mold allows the maintenance of accurate dimensions and ensures fast release of the molded part.

The molded material has a red-brown color and parts may have a good surface finish with a high gloss. The compound is said to provide improved machinability without sacrifice of physical, chemical and electrical properties.

Pre-Tempered Beryllium Copper Strip Requires No Heat Treatment

Offering many of the features of regular age-hardening beryllium copper, yet requiring no heat treatment, Penntemp, a new type of mill-hardened or pre-tempered beryllium copper is being produced in strip form by *Penn Precision Products, Inc.*, 501 Crescent Ave., Reading, Pa. In comparison to phosphor bronze, the material is said to offer higher strength and hardness, improved fatigue resistance, approximately twice the thermal conductivity, and increased resistance to corrosion. The material is also said to eliminate such difficulties as coil set and poor surface.

Available thicknesses run from 0.001 to 0.025 in., with minimum tolerances ranging from ± 0.0001 to 0.0004 in. depending on thickness. On widths from 1/8 to 5 in., tolerances of ± 0.001 and 0.002 are commonly held. The strip is presently available in five tempers offering different combinations of strength and formability.



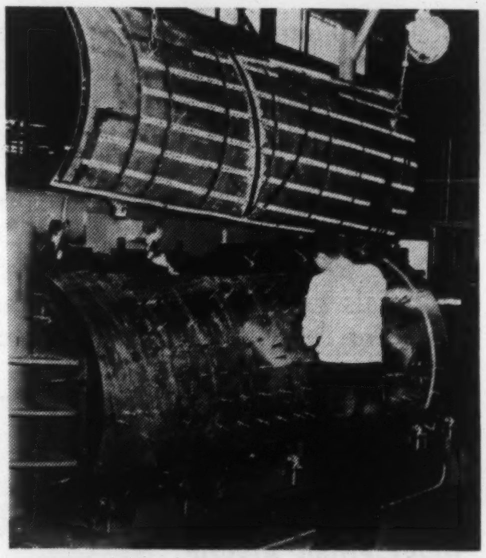
Some typical parts shown with a roll of the new strip material.

Resilient Plastic for Tooling

A new resin formulation developed to meet the need for resilience in tools such as drop hammer punches has been developed by *Kish Resin, Inc.*, 1301 N. Turner St., Lansing 6, Mich. Based on the *Shell Chemical Corp.'s* Epon, an epoxy resin, the Kish formulation is said to retain the low shrinkage qualities of the Epon resins, as well as their high dimensional stability, adhesion and chemical resistance.

Since the shrinkage during cure is as low as 0.0001 in. per in., complicated die contours can be reproduced accurately, eliminating costly machining and hand finishing. The material can be used to provide the surface of the tool, backed with steel, plastics, cast iron or various types of high compressive strength core materials. Repairs can be made rapidly by casting new material over original contour.

The company also handles Epon formulations for casting hard tool surfaces, for core materials and a laminating resin for glass-reinforced tooling. The materials are being used in draw, form and stretch form dies, die strippers, die models, vacuum molds and locators for trim and pierce dies. Checking, holding, drilling, welding and routing fixtures can also utilize the plastic materials. Production drawing and forming on both ferrous and nonferrous sheet metal is possible without loss of dimensional stability or detail. Major advantages entail reductions in tool cost and tool delivery time over conventional methods.

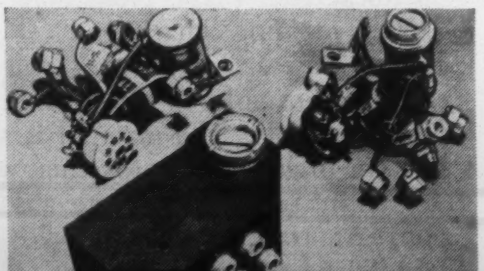


Drill jigs are an example of the use of plastics to make less expensive, light weight tools.

Electrical Casting Resin Has Wide Temperature Range

A newly developed casting resin for encapsulating electronic components is said to have a useful temperature range of —100 to 400 F. For short periods it can be used at 500 F, according to *Emerson & Cuming, Inc.*, 869 Washington St., Canton, Mass.

The cured plastic has a low thermal coefficient of expansion, allowing the embedding of large metallic elements with no cracking during temperature cycling. Called Stycast 2850 GT, the material is said to have a low shrinkage during curing, and good adhesion to a variety of materials. The cured resin is reported to have a flexural strength of 13,300 psi, a heat distortion point of 347 F, a volume resistivity of 5 x 10^{16} ohm-cm, and a dielectric strength of 455 v per mil.



Miniaturization is aided by encapsulating components.

New Materials, Parts and Finishes continued

New adhesive provides good bond between Silastic and aluminum.

New Adhesive Bonds Silicone Rubber

A new adhesive which sets up without pressure in 24 hr at room temperature has been developed for bonding silicone rubber to itself or to aluminum, magnesium, stainless steel, butyl or saran rubber. Produced by *Dow Corning Corp.*, Midland, Mich., and called Dow Corning A-4000, the adhesive is blended with 2.5% by weight of the accompanying Catalyst XY-22 for use. A uniform film is then brushed on the surfaces to be bonded and allowed to air dry until tacky. The coated parts are pressed firmly together to eliminate air bubbles, and allowed to cure without further pressure. Considerable bond strength is said to develop within 24 hr, and a maximum in 3 to 7 days.

Peel strengths of 15 psi, measured according to MIL-C-4003, has been obtained between extruded Silastic and aluminum. With molded silicone rubber, peel strengths fall in the range of 9 psi. Though the bonds obtained with extrusions are better than those obtained with molded silicone rubber, in both cases they exhibit heat and creep resistance at temperatures up to around 200 F.

Fluorocarbons and Silicones Combine in Tough New Rubber

The fluorocarbons and silicones have been combined in a new group of rubber materials said to have high tear resistance and to maintain their resilience over a wide temperature range. Called Tufsils and developed by the *Pacific Molded Products Co.*, 905 E. 59th St., Los Angeles 1, the materials can be fabricated into any shape or form possible with conventional rubber processing techniques.

The Tufsils range in hardness from 50 to 85 Shore A durometer and have a high degree of resistance to fuel and oil. The materials have a tear resistance of around 210 lb per in., and maintain their resilience through a temperature range of –120 to 550 F. According to the company, they should be considered for use where the weakness of silicones poses a problem.

Typical physical properties of a Tufsil material are as follows:

Ten. Str., Psi	850
Elong. at break, %	312
Tear Str., Crescent, Psi	210
Hard., Shore A durometer	65
Comp. Set, 70 hr @ 300 F	29

Glass-Filled Plastic Has High Arc Resistance

A glass-filled electrical grade melamine molding material designated Melmac 3135, with an arc resistance of 180 to 190 sec (ASTM D-495-42) and a heat distortion point of around 400 F has been developed by *American Cyanamid Co.*, 30 Rockefeller Plaza, New York 20.

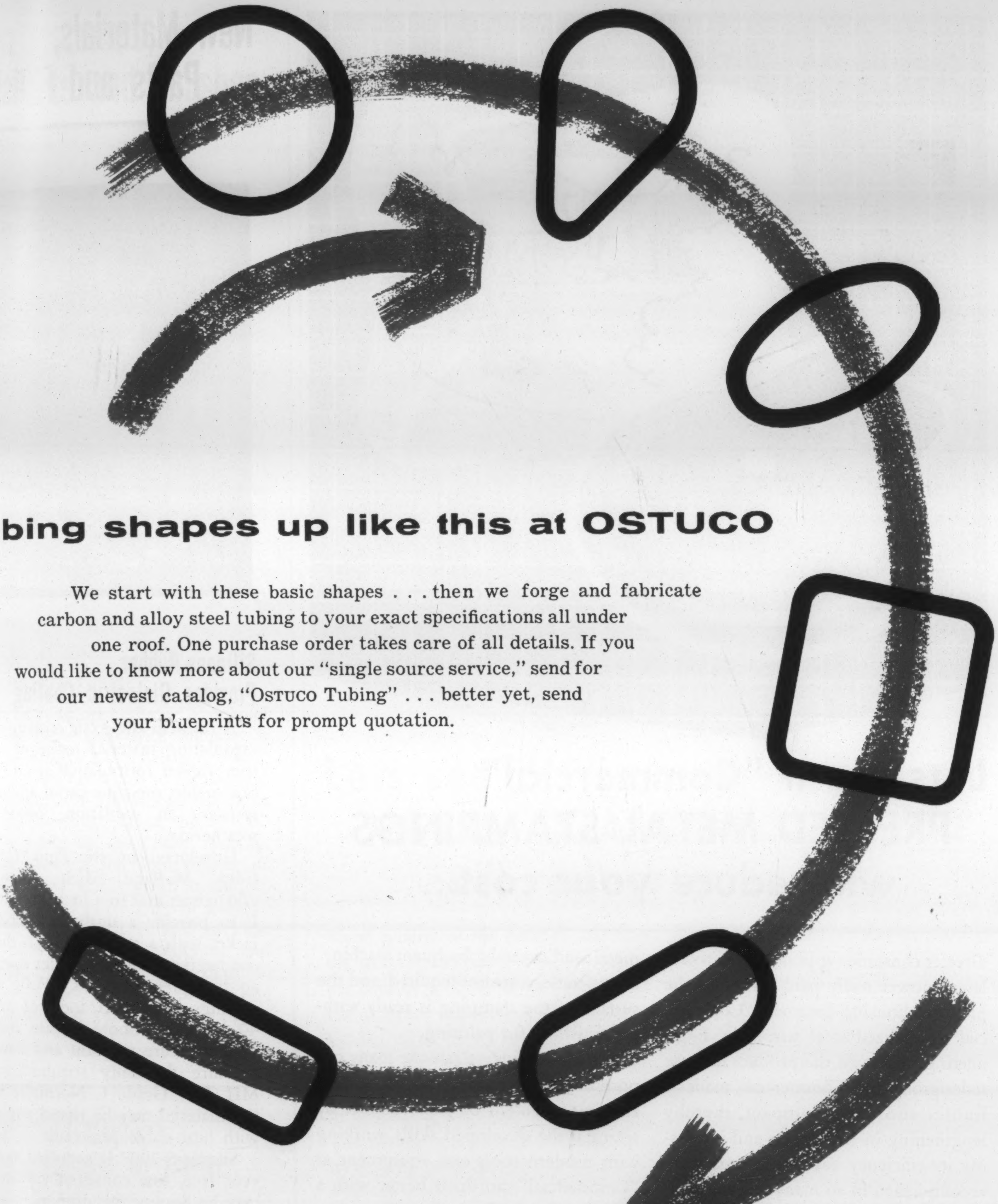
The molding characteristics, including flow and cure time are generally comparable to those of rag-filled materials. The material is said to have high strength together with low shrinkage and moisture absorption. Arc-tracking characteristics are said to be of a high order. The properties listed below indicate the suitability of Melmac 3135 for electrical switchgear applications.

(Continued on page 152)

Tentative Properties of Melmac 3135

(Glass Filled)

Property	ASTM Test	
Compression Ratio (Bulk Factor)	Loose-packed	7-9
Tabletting	—	Hand Only
Plasticity Range	—	Medium
Moldability in Compression Molds	—	Good
Compression Molding Temp, F	—	290–310
Compression Molding Pressure, Psi	—	4000–8000
Moldability in Transfer Molds	—	Limited
Specific Gravity	D-71-27	1.94–2.00
Molded Density, Gms/cu in.	—	31.8–32.8
Machining Quality	—	Poor
Heat Distortion Point, F (264 Psi)	D-648-45T	400
Flammability	—	Self-Exting.
Water Absorption (24 hr @ 25 C), %	4 in. x 1/8 in. Disc.	0.09–0.21
Color Possibilities	—	Natural Only
Impact Strength, Izod, Milled, Ft, lb/in.	D-256	4.00–6.00
Flexural Strength, Psi 1/4 x 1/2 x 5 in.	D-790	10,000–16,000
Deflection, In. (1/4 x 1/2 x 5 in.)	D-790	0.060–0.072
Tensile Strength, Psi	D-638	5800
Dielectric Strength, Short Time 1/8 in. v/m	D-149—44	320–350
Dielectric Strength, Short Time 100 C	D-149—44	200–220
Dielectric Constant, 1000 Cycles	D-150—45T	7.6
Dissipation Factor, %, 1000 Cycles	D-150—45T	3.9
Arc Resistance (ASTM), sec	D-495—42	180–190



tubing shapes up like this at OSTUCO

We start with these basic shapes . . . then we forge and fabricate carbon and alloy steel tubing to your exact specifications all under one roof. One purchase order takes care of all details. If you would like to know more about our "single source service," send for our newest catalog, "OSTUCO Tubing" . . . better yet, send your blueprints for prompt quotation.

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STEEL TUBING
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For more information, turn to Reader Service Card, Circle No. 344

Lets see if "Commercial" PRESSED METAL STAMPINGS will reduce your cost...

Greater consumer appeal of this rotary lawn mower really paid off when the platform housing became a "Commercial" specialized steel stamping. Engineering improved the product because redesigning by "Commercial" made it lighter and more compact, thereby lengthening its life service and increasing its efficiency. Savings in cost were accomplished in so many ways, as usually is the case when a specialized stamping goes into a final assembly. Breakage is eliminated, there is a substantial reduction of the amount of metal used, several subsequent machining operations are not required, and the surface of the stamping is ready without finishing for painting.

You may well investigate the many opportunities for production economies and improvement of your product by seeing if the developed skills, working with modern tools and equipment, at "Commercial" can do it better with a specialized steel stamping. "Commercial" are stamping specialists who produce a lot of unusual stampings. We will be glad to assist in your design.

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"PRODUCTS PREFERRED BY CUSTOMER ACCEPTANCE"

THE COMMERCIAL SHEARING AND STAMPING COMPANY
Youngstown, Ohio Chicago, Illinois- Salt Lake City, Utah

STAMPINGS • FORGINGS • TANK HEADS

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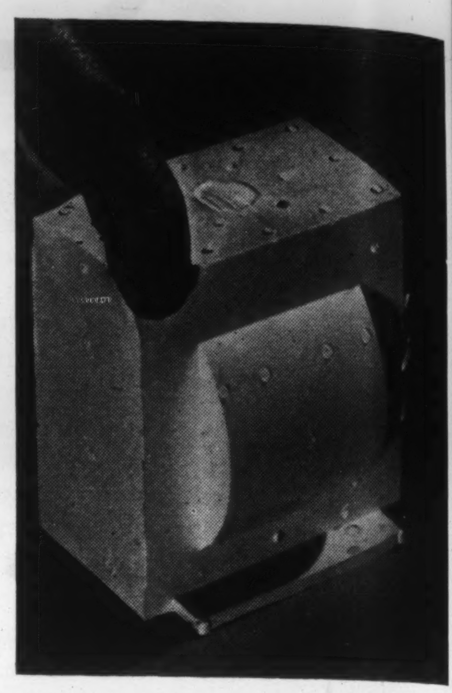
New Materials, Parts and Finishes



Silicone Rubber Provides Dielectric Coating

A resilient dielectric coating or encapsulating material made of a silicone rubber formulation is said to be heat-stable, moisture-proof and highly resistant to oxidation, ozone and weathering.

Developed by the *Dow Corning Corp.*, Midland, Mich., Silastic S-2007 cures in 2 to 4 hr at around 400 F to provide a uniform rubber-like jacket with a relatively high thermal conductivity assuring cooler operation at high temperatures. Fully cured coatings have a hardness of around 40 durometer, Shore A scale, and pass both moisture resistant and low temperature flexibility requirements of MIL-T-27 Grade 1. Normally white, the material may be tinted any shade with heat-stable pigments.

Silastic S-2007 is supplied as a solvent free, low consistency paste and may be applied by dipping, vacuum impregnating, or may be molded in encapsulating molds.

New Nylon Resists Outdoor Exposure

A new formulation of Zytel nylon resin is said to provide resistance to ultraviolet degradation, which will allow applications involving prolonged outdoor exposure. In appearance the material is jet black, and preliminary work indicates that it is readily moldable with good gloss, free from smears and dull spots.

According to the producer, *E. I. du Pont de Nemours & Co., Inc.*, Wilmington, Del., the properties of the material, designated Zytel 105 BK-10, are said to be comparable to those of general purpose Zytel 101 nylon resin, which is now being used industrially for gears and bearings, etc. Applications are anticipated in agricultural machinery, sporting goods, toys and electrical equipment as well as in the automotive field and in the manufacture of marine hardware and accessories.

Colored Titanium Enamel Frit Resists Fading

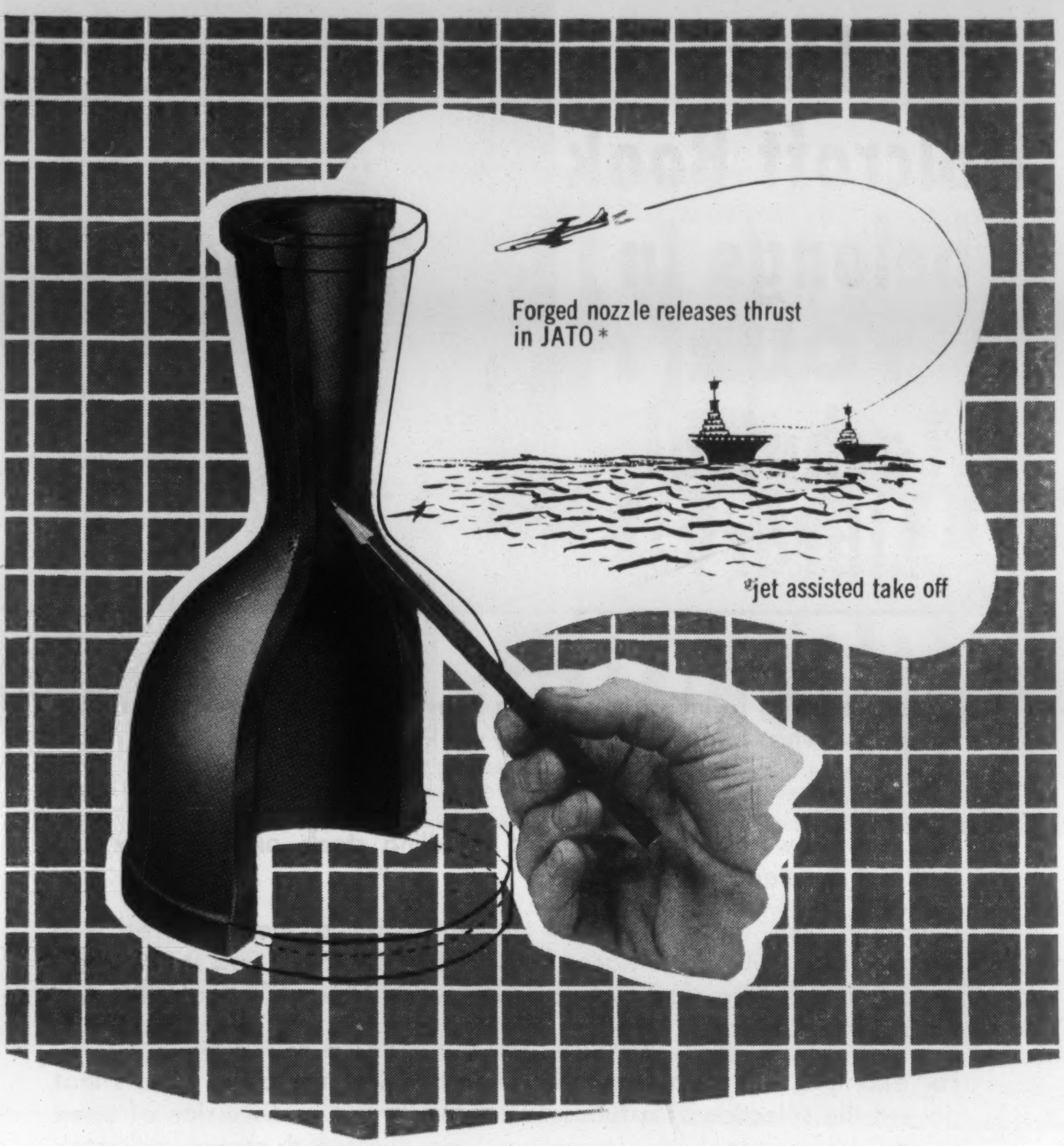
A new colored titanium enamel for the home appliance industry is said to possess high stability, resulting in good resistance to fading and color variance. Developed by *Ferro Corp.*, Cleveland, Ohio, the "1700" frit is made by the "flake" process which involves the cold rolling of near molten glass, which is said to produce good uniformity of flake.

The "1700" frit is said to have the same order of adhesion and thermal properties as white titanium porcelain enamels, and to produce the same type of high gloss finish.

Plastic and Steel Join in Material for Tooling

A putty-like material consisting of fine steel powders and plastic has been developed for use in making tooling, duplicating machine masters, models, prototypes and for caulking large holes in metal castings.

Produced by the *Chemical Development Corp.*, Danvers, Mass., Devcon can be worked like modeling clay and requires no heat or pressure to use. A hardening agent is added when cure is desired. According to the company, the material will adhere well to steel and has high impact, tensile and compressive strengths. The cured material can



Forged nozzle releases thrust in JATO*
*jet assisted take off

Lets see if "Commercial"
METAL QUALITY FORGINGS
will reduce your cost...

Metal quality of the nozzles releasing the tremendous thrust which assists in the launching of carrier jet aircraft is of life or death importance. The slightest hidden metal defect in the "as-rolled" steel would become apparent during the external and internal upsetting used in producing this forged nozzle.
The savings in cost of this metal quality forging produced by "Commercial" was more than enough to absorb shipping costs for a distance of nearly 1000 miles.
Should you have problems involving the use of formed metal parts requiring durability, efficient positioning of metal for required strength and finishing—let's see if "Commercial" forgings will not give you a lower cost by saving metal and eliminating rejects before any machining is done. And don't fail to recognize that forgings combine strength with toughness for greater wear resistance and shock load. "Commercial" are forging specialists who produce a lot of unusual forgings. We will be glad to assist in your design.

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Youngstown, Ohio · Chicago, Illinois · Salt Lake City, Utah

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This
Holcroft Book
belongs in
YOUR
Technical
Library

Blazing the Heat Treat Trail with HOLCROFT

"We are going to invest in our own heat treat furnace. Where should we start—what furnace facts should we know?"

"Do we know the difference between 'direct' and 'indirect' firing?"

"Do we know all the methods of handling stock, and which would best suit our needs?"

Questions like these are best answered by a manufacturer who specializes in building furnaces for specific jobs. You'll find the answers—compiled from a world of experience—in Holcroft's book "Blazing the Heat Treat Trail."

For example, there's a frank discussion of all of the basic factors that govern the selection of a furnace: the fuel to use, a discussion of open firing versus controlled atmospheres, an illustrated section on stock handling, and suggestions as to how your heat treat process can be tied right into the production line.

This book represents the type of industry service that stamps Holcroft as its leader. As continuing sources of information, future advertisements will further describe different furnace types and methods of handling stock.

You'll find it's a good bet to come to Holcroft first!

Want a copy of this book for your files? Just write—right now!

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PRODUCTION HEAT TREAT FURNACES FOR EVERY PURPOSE

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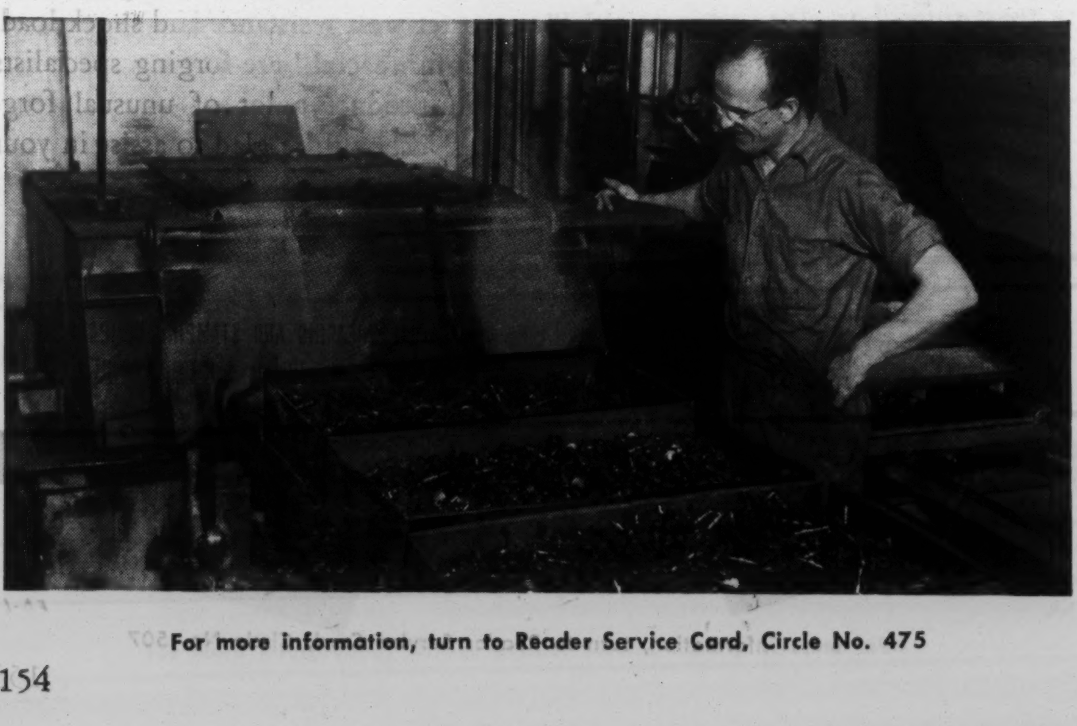
CANADA: Walker Metal Products, Ltd., Windsor, Ontario EUROPE: S.O.F.I.M. Paris 8, France



For more information, turn to Reader Service Card, Circle No. 475

New Materials, Parts and Finishes

be plated with chromium, nickel or copper or metallized by conventional methods. It is said to have a high order of resistance to solvents, acids, oils and other chemicals.

New Cellulose Polymer Makes Tougher Lacquers

A high degree of toughness, clarity, flexibility, ultraviolet resistance and stability are claimed for lacquer films made from a new cellulose polymer, half-second butyrate. The weather resistance of the new polymer is better than that of any other clear film forming material which can be incorporated into an easily sprayable lacquer, according to the producers, *Eastman Chemical Products, Inc.*, Kingsport, Tenn.

Films made with the polymer are said to be particularly effective in protecting aluminum. For instance, in the fabrication of components of structural aluminum, it is suggested that the finished sections be coated with a lacquer made with half-second butyrate. According to reports, the film will protect the aluminum from the possibility of damage from the strongly alkaline fresh mortar used for construction.

New Iron Alloy Resists Abrasion

A new abrasion-resistant iron alloy which the company claims can be heat treated to 700 Brinell has been developed by the *Taylor Wharton Iron and Steel Co.*, High Bridge, N. J. According to the company, the alloy, called Tisco 150-Y, can provide substantial savings in plant operations by the longer life of the material.

The alloy has been used successfully in blades for the propulsion of blasting grit and steel shot in centrifugal blast cleaning equipment; tube elbows in pneumatic metal chip handling systems in automotive plants; brick making equipment; mixer paddles and in equipment used to process materials containing tramp iron, sand and other abrasive matter.

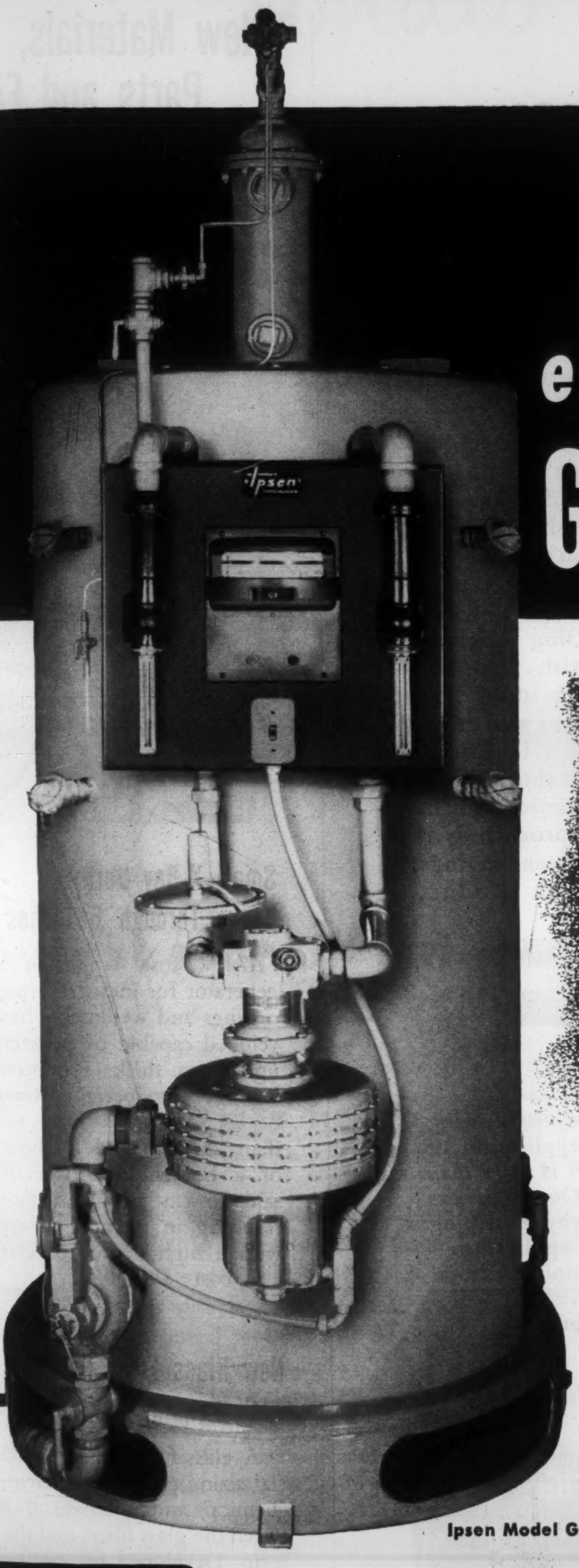
(Continued on page 156)

IPSEN

endothermic

GENERATORS

GAS-FIRED



A complete line of Ipsen Generators, gas-fired, with output capacities ranging from 250 to 5000 C.F.H. is now available with all of the proven features of other Ipsen electric endothermic units. Specific features of the gas-fired models include multi-jet burners and an inconel retort, automatic temperature control of water-cooled heat exchanger, double exhaust vents, and automatic protective devices that assure efficient operation within a safe temperature range.

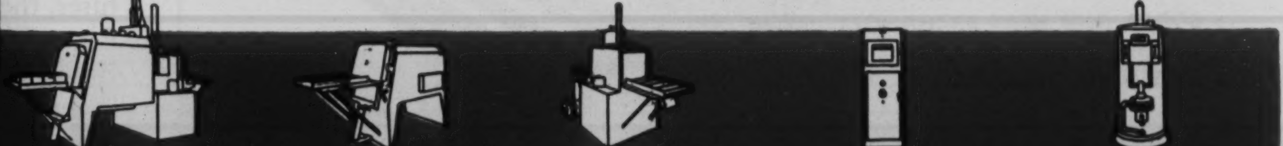
FREE BULLETIN—Write for complete data and specifications on these new units today.

Ipsen Model G-1250-G Gas-Fired Generator

AUTOMATIC
Ipsen
HEAT TREATING UNITS

Universal Production Units in Standard Sizes 100 to 2000 LB./HR.

IPSEN INDUSTRIES, INC. 720 SOUTH MAIN STREET, ROCKFORD, ILLINOIS


Controlled Atmosphere Heat Treating Units
Controlled Atmosphere Tempering Units
Automatic Washers
Dewtronik and Carbotronik Controllers
Atmosphere Generators

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STANDARD CYLINDER TUBING

"Mirror Finished" to precision tolerances, it's used in automobile shock absorbers, power steering, hydraulic pumps . . . without further sizing or finishing.

Here's a busy part of an automobile shock absorber that's built for brutal punishment. It's Standard's modern "mirror-finish" Cylinder Tube. So that it won't weaken or leak under punishment, every inch of this tubular "toughie" must measure up to exacting specifications—in cylinder finish . . . in I.D. tolerances as close as .001" . . . in extreme uniformity of wall thickness and concentricity . . . in internal pressure resistance, to shocks up to 9000 P.S.I. The elimination of broaching or further processing of any kind effect significant savings for our customers in product assembly.

As you see here, the engineering involved behind the application of tubing to your product is *more than skin deep at Standard.* Our engineers will gladly show you why in helping you with your tubular application—whether it involves a simple structural or mechanical member . . . or a precision application.

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MAKE "STANDARD" YOUR SOURCE FOR—
- WELDED MECHANICAL TUBING
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- BOILER AND HEAT EXCHANGER TUBING
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STEEL TUBING SIZES: ½" O.D. TO 5½" O.D. — .028 TO .260 WALL.
STAINLESS SIZES: ¼" O.D. TO 4½" O.D. — .020 TO .154 WALL.

For more information, turn to Reader Service Card, Circle No. 370

New Materials, Parts and Finishes

Small X-Ray Unit Looks Through 5 Inches of Steel

A low cost, 1 million volt x-ray generator for industrial inspection of castings and weldments has been developed capable of penetrating steel up to 5 in. thick. Produced by *High Voltage Engineering Corp.*, Cambridge, Mass., the unit weighs less than 2500 lb and is about the size of a household refrigerator. It is said to cast sharp x-ray shadows, resulting in pictures or radiographs with a high degree of clarity. The unit costs $25,000.

New Glass Fiber Roving Aids Bonding of Plastic

A glass fiber roving utilizes a special sizing process to provide a better chemical and mechanical bond between the glass fibers and the molding resin. Developed for preform molding of reinforced plastic products, the material has been designated Pittsburgh 508 Roving by the manufacturer, the *Fiber Glass Div., Pittsburgh Plate Glass Co.,* 632 Fort Duquesne Blvd., Pittsburgh 22, Pa. The roving is reported to have good wetting-out characteristics and adherence to contour, providing better pattern design.

(Continued on page 158)

what's new?

NO. 29 OF A SERIES.

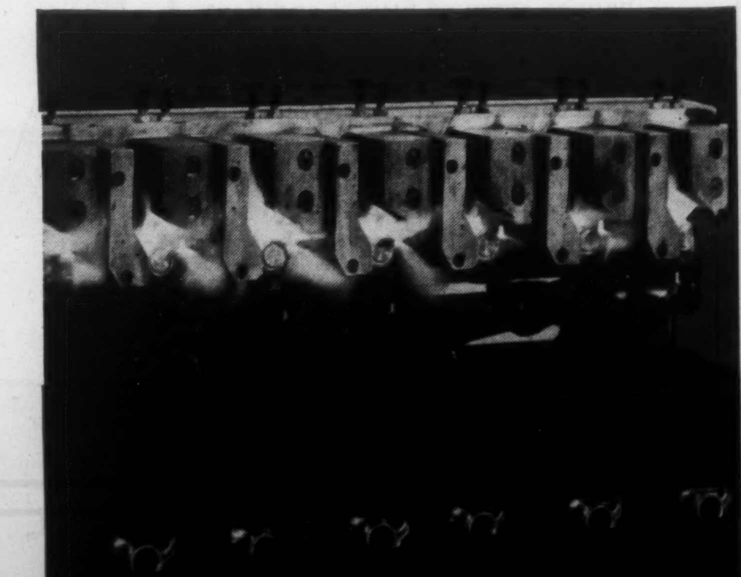
in tight spots like these...

flamatic puts heat where you want it

You pick the spot, and a **flamatic** puts heat precisely where you want it. In this selective heating application, for example, a two-station **flamatic** spot hardens cups and pads on automotive rocker arms. The machine hardens 7 pieces to Rc 60 in one station while the operator loads the other.

This is another example of **flamatic's** on-the-spot solution of selective heating problems, combined with ingenious tooling to meet specific production requirements.

This combination has paid off in profitable production of many other parts, in commercial heat treat shops and large plants. Cincinnati Flamatic heat engineers will be glad to apply their skills to your needs. Call them in, or write for Publication No. M-1861.



CINCINNATI flamatic

PROCESS MACHINERY DIVISION
THE CINCINNATI MILLING MACHINE CO.
CINCINNATI 9, OHIO, U.S.A.

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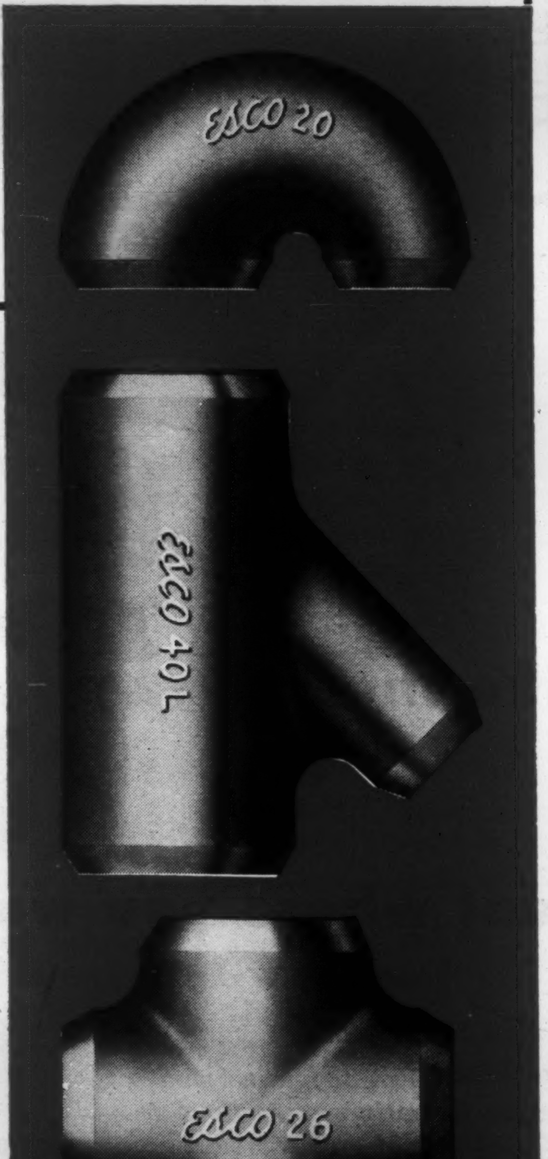
ESCO

WELDING FITTINGS CAST IN ALL CORROSION and HEAT RESISTANT ALLOYS

give you freedom of design on piping systems



You no longer need to let alloy problems or unusual shapes or sizes of fittings limit the design of your piping systems. *ESCO* can supply you with fittings of all standard corrosion and heat-resistant alloys, including 0.03 max. carbon, or specially modified alloys in wall sections and dimensions to meet your most exacting requirements.

You get fast delivery, even on small quantities. No waiting for long runs of standard production items to be completed before your job can be started. Big orders can be handled efficiently and economically, too. *ESCO* pays the freight on orders of $300 or more.

ESCO also offers you centrifugally-cast Spuncast® pipe, all types of flanges, screwed fittings and flanged fittings cast specifically to meet your needs and analyses. Complete engineering assistance for your piping system is available, if needed. Ask for details or write for free booklets "*ESCO* Stainless and High Alloy Products for the Process Industry" ..."How to Cut Costs With *ESCO* Spuncast". . ."*ESCO* Cast High Alloy Fittings".

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Salt Lake City, Utah
Honolulu, Hawaii
In Canada, Vancouver, British Columbia and Toronto, Ontario

For more information, turn to Reader Service Card, Circle No. 383

New Materials, Parts and Finishes

Tungsten Coating Protects Variety of Materials

A coating consisting of tungsten particles suspended in a liquid plastic has been developed for paint-on protection and surface hardening effect by *The Lockrey Co.*, Southampton, N. Y. The material also incorporates molybdenum disulfide to provide built-in lubrication.

Called Tungstide, the coatings are available in various formulations for different uses. They can be supplied for air-dry application to plaster of Paris, wood, masonite, and plastics; for baking on metal; and for special high temperature applications. All grades are said to be water and solvent resistant, and may be applied to any surface of the appropriate material. In cases where they are to be used with plastics and a high degree of dimensional accuracy is necessary, they may be brushed directly on the inner surface of the mold and cured integrally with the plastic form.

Tungstide may be applied by brush, dip or spray in any desired thickness. It is expected to find use in the plastic sport car body and in the aircraft field for sheet metal forming molds and tools, for reducing wear on plastic drilling, assembly and checking jigs, to reduce wear on vacuum forming molds, and on plastic parts which encounter a considerable amount of sliding wear in service.

Weldable Titanium Sheet Commercially Available

Rem-Cru A-110AT titanium alloy is now in commercial production in sheet form at *Rem-Cru Titanium, Inc.*, Midland, Pa. The weldable high strength alloy contains 5 aluminum, 2.5% tin and the balance titanium. The sheet is being supplied in thicknesses down to 0.025 in. holding close flatness tolerances.

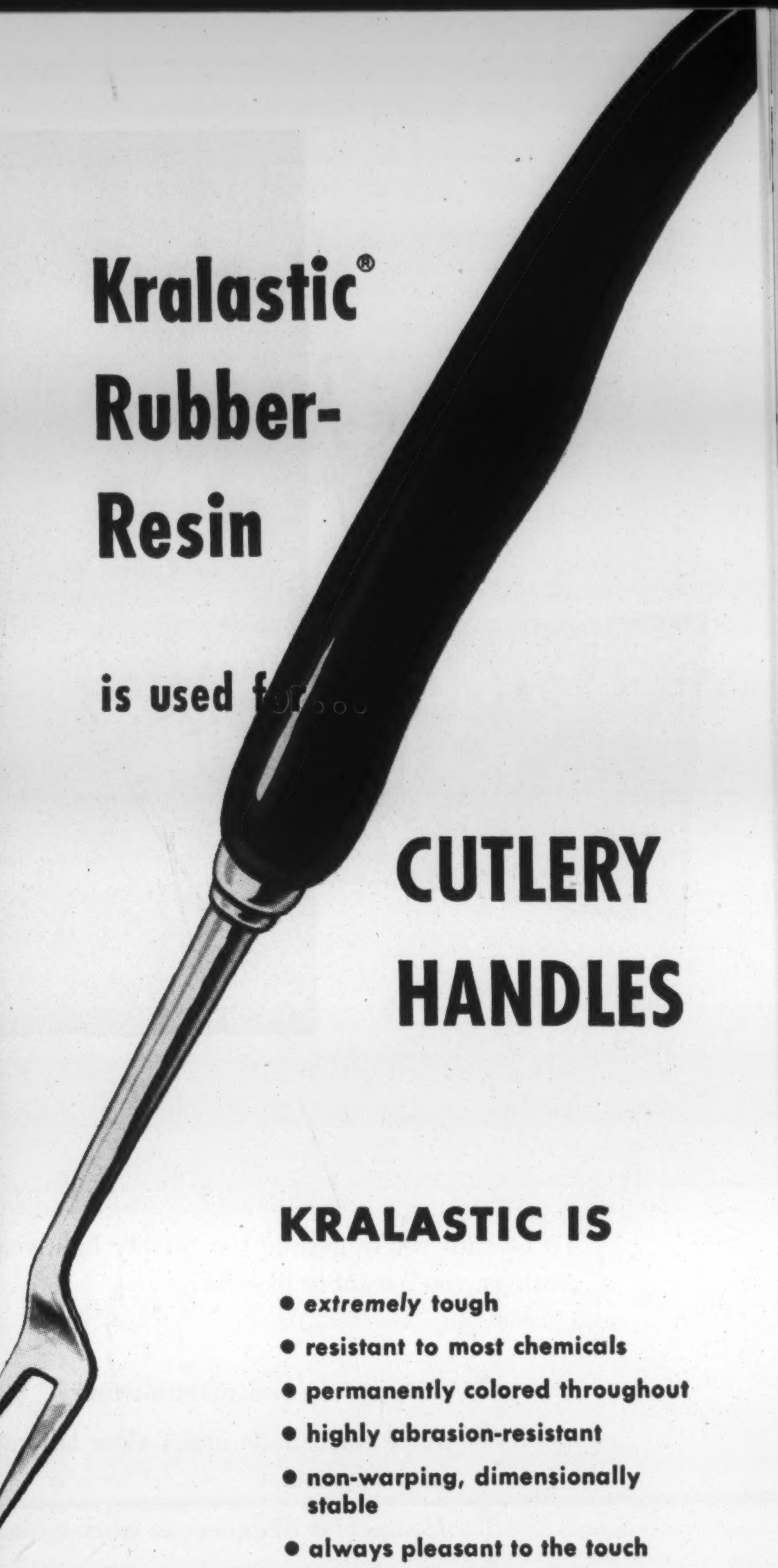
Two New Insulating Materials

Developed primarily for insulating motors, generators and transformers, two new insulating materials—one

For more information, Circle No. 498

→

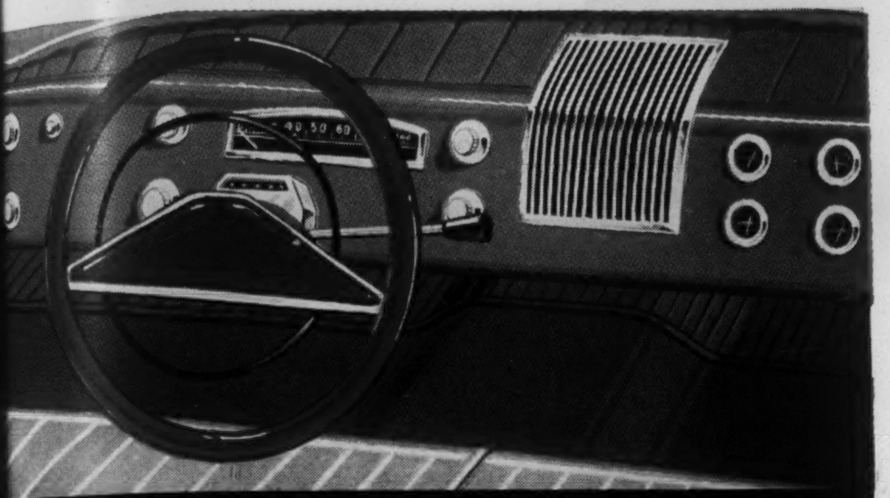
HERE'S WHY



Kralastic® Rubber-Resin

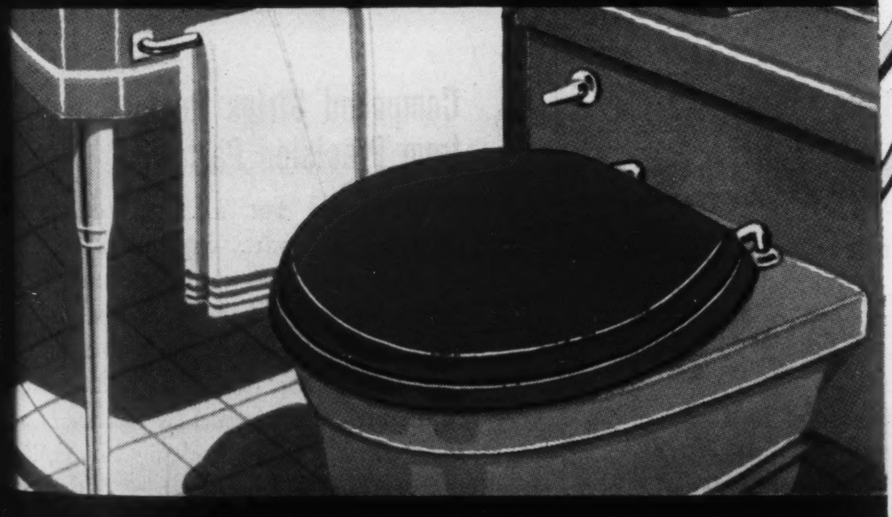
is used for...

CUTLERY HANDLES



WHY NOT...Kralastic rubber-resin for *steering wheels?*

WHY NOT...Kralastic rubber-resin for *tool handles?*



WHY NOT...Kralastic rubber-resin for *toilet seats?*

KRALASTIC IS

- *extremely* tough
- resistant to most chemicals
- permanently colored throughout
- highly abrasion-resistant
- non-warping, dimensionally stable
- always pleasant to the touch

Why not Kralastic for a *thousand and one* applications where its great toughness, light weight, dimensional stability, and other valuable properties can increase both *performance* and *saleability?* Kralastic has already proved a boon to *hundreds* of manufacturers. And it might well do the same for *you.* Why not find out?

Naugatuck Chemical

Division of United States Rubber Company

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NAUGATUCK, CONNECTICUT

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on the lighter side
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To be sure you're getting top quality lightweight castings, you'll want to look for:

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For more information, turn to Reader Service Card, Circle No. 522

New Materials, Parts and Finishes

for lower cost applications, the other for high dielectric strength and toughness—have been marketed by the *National Vulcanized Fibre Co.,* Wilmington, Del.

NACO Insulation is a 100% rag-base type of vulcanized fiber which, according to the manufacturer, has a density lower than that of conventional rag papers, reducing the cost 20 to 30% per ft. It is available in sheets, rolls and coils in thicknesses up to 1/32 in.

NACO-Mylar Combination Insulation is NACO Insulation combined with Mylar, a DuPont polyester film. It was developed primarily for motor slot and transformer insulation where requirements demand high dielectric strength and toughness. The material is also said to have good cuffing properties. The Mylar can be applied to one or both sides of the rag-base material in thicknesses from 0.0005 to 0.005 in.

Compound Strips Rust from Precision Parts

Designed for alkaline de-rusting of precision parts where dimensional change and acid embrittlement must be avoided, Oakite Rustripper is also said to have proved effective, in certain cases, for descaling heat-treated titanium. Developed by *Oakite Products, Inc.,* 19 Rector St., N. Y., the material is a heavy-duty, off-white powder that may be used in hot or cold solutions.

According to the manufacturer, it may also be used with direct current to remove deep-pitted rust, or reverse current to remove heat scale. Other advantages claimed for the material are: 1) it will not attack sound metal; 2) it will not cause hydrogen embrittlement; 3) it does not require special equipment such as stainless steel tanks; 4) it creates no troublesome fumes; 5) it strips certain types of paint at the same time as it removes rust; and 6) it protects against new rust attack.

(Continued on page 162)

*Enthonics** AT WORK Protecting Zinc, Cadmium, Copper, Brass, Steel

ENTHONE CORROSION PREVENTIVES

Stand up to Salt Spray

At Enthone our sole aims are the development of better methods for the improvement of metal finishing and the reduction of finishing costs. These we have accomplished in the field of corrosion prevention. Our research chemists and engineers are responsible for the following outstanding metal finishing products for the prevention of costly corrosion:—

ENTHOX: Puts iridescent, gold-colored chromate coating on zinc and cadmium. An excellent base for organic finishes. Highly resistant to corrosion; withstands salt spray from 100 to over 1000 hours.

COMPOUND 39: A one-operation phosphating and cleaning compound for steel and zinc. Fine grained, highly adherent phosphate coat is ideal base for organic finishes. Gives high bond strength.

EBONOL "C": Gives jet black cupric oxide coating to copper and its alloys. Chemically stable; heat stable; very adherent. Fine base for organic finishes. Readily withstands salt spray.

COMPOUND NR-31: A rustproofing agent for iron and steel. Leaves thin surface film that prevents rusting when drying water off metal or when storing parts in water. Quickly removed by rinsing in water.

COMPOUND NR-37: An organic rust-inhibitive compound that prevents rusting while evaporating water from steel or iron following hot or cold rinsing. The compound evaporates as the water evaporates, leaving the surface ready for organic coating.

COMPOUND NR-40: A neutral degreasing and rustproofing compound for iron and steel. Imparts light, corrosive-resistant film. Cleans, temporarily rustproofs in one operation. Excellent for hot water drying of steel.

RUSTPROOFING OIL NO. 15: A polar solvent-type rustproofing oil that leaves thin film on metal. Safety solvent with flash point well over 100°F. Completely sheds water. Has a salt spray resistance of 15 to 24 hours.

RUSTPROOFING SOLUBLE OIL: An emulsifiable, rustproofing material. Corrosion-resisting oil film is created by diluting oil with water. Protects steel against rust for 10 to 15 hours in salt spray.

ENTHONE Chemical Products are formulated to meet specific metal finishing needs. Consult any one of our field representatives or write our research department regarding your finishing problems. They will gladly tell you about the ENTHONE products designed to fit into your production picture — offering operational savings, improved product performance and increased production efficiency. Write today for an obligation-free consultation.

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ELECTROPLATING CHEMICALS

Service Representatives and Stock Points: BINGHAMTON, N. Y., Austin F. Fletcher, Inc.; CHICAGO, Ardco, Inc.; CLEVELAND, R. O. Hull & Co.; DALLAS, Weaver Engineering & Supply Co., Inc.; LOS ANGELES, L. H. Butcher Co.

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You by-pass 3 out of 5 basic production steps . . . . cut costs 15 to 20 per cent or more when you use the Nickeloid Method of producing plated metal parts and trim. That's because Nickeloid Metals are PRE-plated in durable, uniform finishes of chrome, nickel, copper or brass; require no cleaning, plating or polishing.* And you don't have to pamper these versatile metals to retain their beautiful mirror-like finishes. Stamp, blank, bend or draw . . . they fit right into standard production techniques.

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CLEAN
PLATE
ASSEMBLE
POLISH

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The Nickeloid Method eliminates three costly steps

No cleaning, plating, polishing. Just fabricate and assemble. 2 steps instead of 5! Nickeloid Metals are also available with Mar-Not protective coating, a fabrication and handling aid.

***Pre-plated to base metals of steel, zinc, copper, brass and aluminum. Available in sheets and coils, interesting patterns and finishes.**

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24 pages of illustrations and reference-type material covering uses, properties and fabrication techniques for Nickeloid Metals. Send today!

Sales offices in most principal cities

AMERICAN NICKELOID COMPANY, Peru 6, Illinois

For more information, turn to Reader Service Card, Circle No. 504

New Materials, Parts and Finishes

Metallized Polyester Film Provides Stable Colors

Mylar, DuPont's polyester film, has been added to the line of metallized plastic films produced by *Coating Products*, Englewood, N. J. Available in gold, silver, copper and a wide range of other colors, Mirro-Brite Mylar is said to possess a high degree of color stability. According to the company, the colors stand up for 1000 hr on Fadeometer tests. Since the lamination is accomplished with the colored and plated side locked to the material, the surface is said to possess a protective finish offering high resistance to abrasion, solvents and stains.

Adding color to the polyester film is expected to allow interesting applications where the attractive appearance can be coupled with the high impact strength, flex life, stiffness and tear resistance of the film. In addition, it possesses a high dielectric strength and a relatively low power factor.

Because of the good tensile qualities of the film, Mirro-Brite Mylar can be used in gages as thin as 0.00025 for laminations to leather, fabrics, paper and other plastic materials. The metallized material can also be spun and converted into a strong colorful yarn for textiles. Other applications are expected to be found in such fields as shoe, belt, handbag, and novelty industries.

Mirro-Brite Mylar is available in slit-to-size rolls in 20 and 36 in. widths and thicknesses of 0.00025. 0.00050. 0.001, 0.002, 0.005, and 0.0075 in.

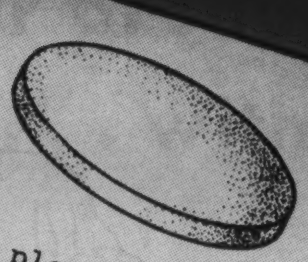
Ready-To-Use Cement Joins Plastic Pipe

A prepared cement called Plasjoin VC, designed for joining rigid polyvinyl pipe has been marketed by *Merritt Products Co.*, 1547 E. 18th St., Cleveland 15, Ohio. Developed in conjunction with *B. F. Goodrich Chemical Co.*, the cement is said to be easily applied, and to set rapidly into tough bonds between pipe sections.

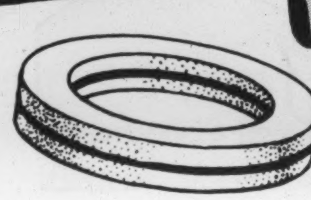
Since the cement is supplied ready-

(Continued on page 164)

American Felt Engineers can help you Reduce Costs... Improve Products

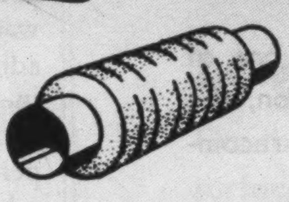


A glass-polishing plant had been purchasing felt discs 1½" thick. Changing to 2" at small extra cost effects appreciable economies. Increased disc life means longer runs without down-time for replacements.

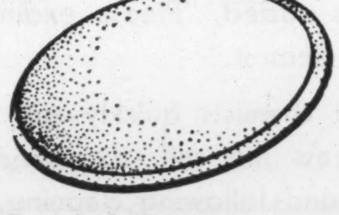


A popular household appliance originally had plain felt seals, held in place by complicated and expensive springs. Switching to Hycar-treated seals eliminated the springs, with consequent economy.

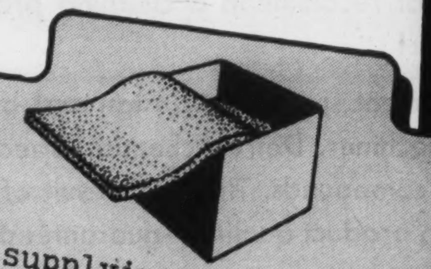
When you take advantage of the knowledge of your suppliers, as well as of their materials, you can often obtain cost-cutting advantages. Here are some recent examples of constructive collaboration between American Felt Company and its customers.



A large user of felt seals now receives them packed on cardboard tubes. The customer states this saves time in assembling.



A filter was re-designed to use fused edges, so that it could be delivered to the customer's plant ready for assembly without any processing whatever.



American was supplying felt strip in rolls. After examining the application, it was suggested that the felt be supplied in cartons, each containing 5,000 feet, the end brought out to the top of the carton, so one strip could be quickly joined to the end of the preceding one. Result: much time saved in replacing rolls.

Felt is an engineering material, available in many types. American's Engineering and Research Laboratory is ready to work with you in uncovering the most suitable and economical felt for your purposes. See the nearest Sales Office, or write direct.

American Felt Company

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SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Dallas, San Francisco, Los Angeles, Portland, Seattle, Montreal. — PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I. — ENGINEERING AND RESEARCH LABORATORIES: Glenville, Conn.

For more information, turn to Reaedr Service Card, Circle No. 306

LOOK TO DETREX FOR Service WITH A Saving

DETREX — rich in years of experience — coordinates Engineering and Chemistry for you . . .

The other day, a metal part came into the Detrex laboratory from one of our field offices. Along with complete information as to its function, the following notation was added, "Please examine the soil and make recommendations on how to clean it."

Detrex engineers and chemists quickly got together. Coordinating their activities, they analyzed the soil, examined the shape, considered the operations preceding and following cleaning, and all other factors. Result: a swift, sure answer to the customer's needs.

Not every query is as complex . . . previous experience on similar problems often provides an immediate solution. But most important is the fact that Detrex will not recommend a cleaning process unless they are positive it is going to work!

Detrex equipment specialists design and build the degreasers, washers, and processing machines. Detrex chemical specialists blend and manufacture the solvents and compounds. The final result of this unique coordination of effort and skill is top product quality—guaranteed results. What more could you ask?

Please have a Detrex field technician come in to discuss our metal cleaning operations and prove how Detrex can cut our costs and improve our quality.

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COMPANY____________________

ADDRESS____________________

CITY__________ ZONE_____ STATE__________

DETREX CORPORATION
DEPT. E-102, BOX 501, DETROIT 32, MICH.

New Materials, Parts and Finishes

to use, mixing time is the field is eliminated, batches are consistent, and small containers can be used handily in field work.

Colorless Emulsion Binds Glass Reinforcing

An emulsion designed for use as a binder for glass mats and molding preforms, which will not discolor during drying or subsequent molding operations, has been developed by *Rohm & Haas Co., Resinous Products Div.*, Washington Square, Philadelphia 5.

Called Binder P-812, it is an acrylic-type water emulsion which forms a hard, colorless, thermoset polymer when heated. According to the company, advantages of the binder over existing binders for glass fibers are: 1) can be subjected to 450 F for 5 min without discoloring; 2) only preparation necessary is dilution with water; 3) high wetting power and adhesion to the fibers; 4) insoluble in styrene and other organic solvents; 5) will not flow at high temperatures; and 6) has high mechanical and storage stability.

As received, the binder has a 45% solids content, a pH of 4.0 to 6.0 and a specific gravity of 1.08 to 1.09. The material is said to be particularly useful in the molding of light-colored pieces, since it introduces no color of its own nor does it discolor when heated. Drying temperatures of over 250 F are recommended. Because of its high degree of adherence and its resistance to heat and solvent attack, the material will not "wash" during molding.

Glass-Reinforced Polyester Sheet

Available in 10 different colors and either flat or corrugated, glass fiber reinforced polyester sheet material has been marketed by the *Plastics Div., the Strick Co.*, Whitaker at Godfrey Ave., Philadelphia, Penna. Called Daycor, the sheet material is standard construction, possessing the properties of conventional glass-reinforced polyester sheet. It is shatterproof, translucent and light in weight. It can be sawed, nailed,

◄ For more information, Circle No. 47

ew Materials, Parts and Finishes

rewed or drilled and, according to he company, cannot rot or warp. olors are integral with material, liminating need for repainting.

lexiglas Sheet Extruded n Thin Gages

Plexiglas sheet is now being comercially extruded in thicknesses own to 0.060 in., by *Rohm & Haas o.*, 222 W. Washington Square, hiladelphia 5. The extruded maerial is said to be priced lower than ast sheets and is suitable for outoor as well as indoor use.

The sheets are available in thickesses of 0.060, 0.080, 0.100 and .125 in., in widths of 36 and 48 n., and lengths from 48 to 96 in. t is marketed in both transparent nd translucent form. According to he company, extruded sheet material s expected to find many applications here there has been a need for thin-hin-gage, lower-priced material with he properties of cast acrylic plastic.

ew Electrodes and A Solder Paste id Copper Joining

Four new welding electrodes and paste solder have been marketed by *utectic Welding Alloys Corp.* 40-40 72 St., Flushing 58, N. Y., for the oining of copper and copper-base aloys. EutecTrode 280 DC is said to ave good weldability and high tenile strength and corrosion resistance. t is designed for joining ferrous etals and copper alloys.

EutecTrode 300 DC is said to yield high copper deposit and may be sed without preheating the base meal. According to the company, a pecial coating permits the electrode o provide the necessary heat while a ong arc is held, and when the arc s shortened deposition begins, yielding deposits said to be similar to hose provided by inert gas welding.

EutecTrode 1850 AC and 1850 DC reduce lengthy preheat operaions and are designed for joining opper and bronze. EutecTrode 1840 DC is said to be similar to the 1850 ods, but to provide weldments with higher machinability.

Eutec-CopWeld is a copper solder in paste form. The material can be painted on the parts to be joined, and with the application of heat a high strength bond is said to result.

For more information, Circle No. 474 ➤

LOOK TO DETREX FOR Service WITH A Saving

Add life to your product's paint finish . . . with

DETREX Paintbond

Paintbond's fine-grained crystalline structure gives added life to paint finishes in two ways. First, Paintbond provides secure anchorage—literally locks paint to metal surfaces. It also stops corrosion in its tracks. If a painted surface gets scratched Paintbond minimizes the damage—confines rust to the scratched area—puts an end to paint flaking and peeling.

Paintbond adds life to product appearance, too. Its fine-grained crystals provide a smoother surface and thus a more lustrous paint finish for added product appeal.

Lower cost, flexible processing, too

On the job, Detrex Paintbond lowers costs by coating a greater surface area per drum of compound. Moreover, it has been proven that Paintbond substantially reduces maintenance, too.

You'll also appreciate its flexibility. Whether you apply it by spray or by immersion, Paintbond is easily controlled to give exactly the coating weight and *crystal size* you desire. All in all it adds up to real savings both in compound cost *and* operating costs.

PEDIGREE *for* PAINTED PRODUCTS

This finish is LOCKED ON with... DETREX Paintbond QUALITY FEATURE

Detrex makes available to Paintbond users an attractively designed sticker for application on their finished products. At point of sale this sticker becomes another sales clincher for your product by informing the customer of the life-time, rust-free paint finish that Paintbond provides.

Like all Detrex processes, Paintbond is fully guaranteed. You can get all the facts by using the coupon below.

Please send us complete facts about Paintbond and how it will improve our finishes while cutting our costs.

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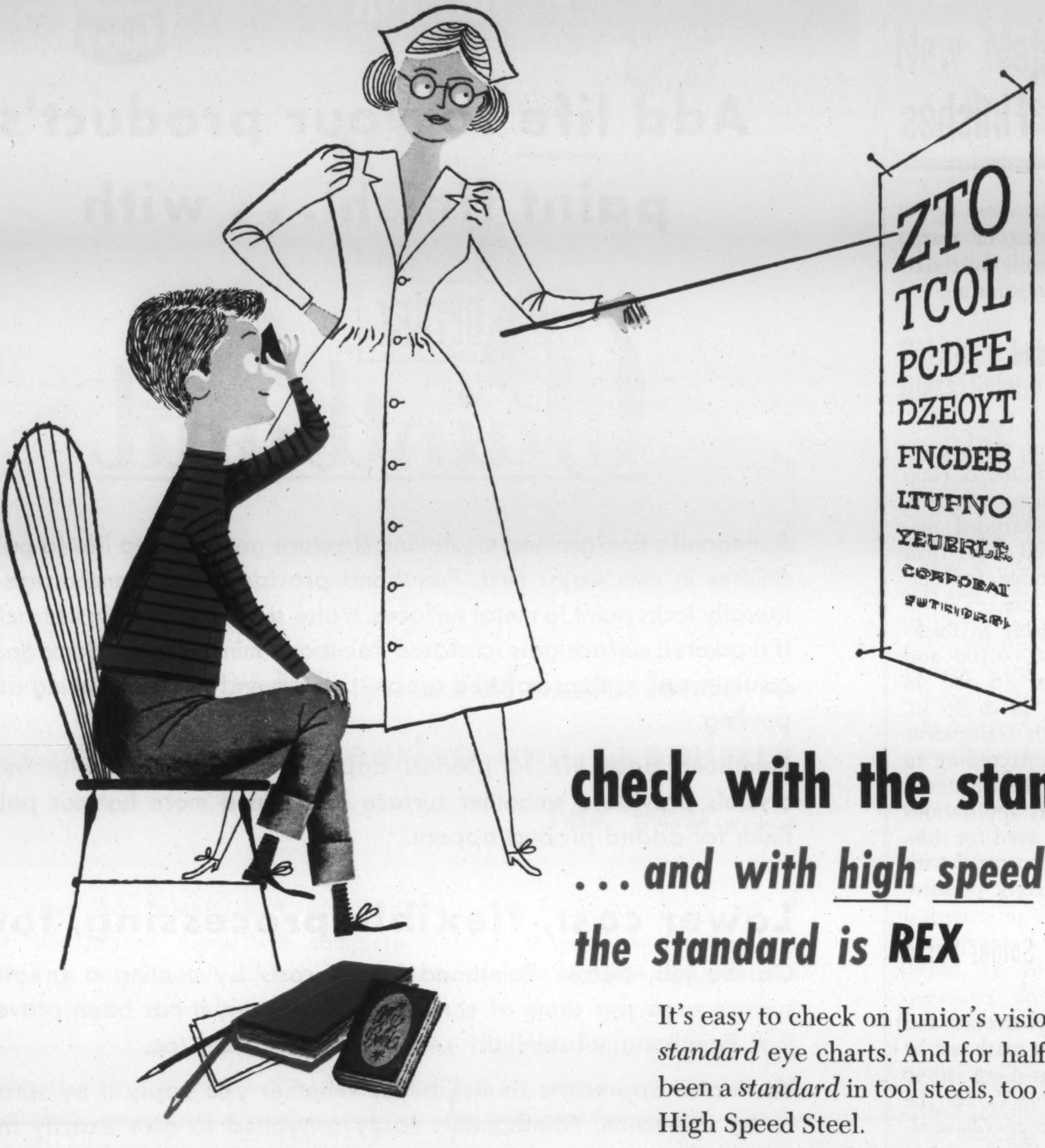
CITY__________ ZONE_____ STATE__________

DETREX DETROIT

DETREX CORPORATION
DEPT. PB-202, BOX 501, DETROIT 32, MICH.



check with the standard

. . . and with high speed steels the standard is REX

It's easy to check on Junior's vision these days with *standard* eye charts. And for half a century there's been a *standard* in tool steels, too — Crucible REX® High Speed Steel.

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That's because REX High Speed Steels are unsurpassed in structure, finish, carbide distribution, response to heat treatment and general uniformity. So, on your next purchase of high speed steel, specify REX — made only by Crucible.

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For more information, turn to Reader Service Card, Circle No. 417

Contents Noted

A digest of papers, articles, reports and books of current interest to those in the materials field.

This Month:

- *Bonding vs Riveting Aluminum*
- *Beryllium Powder Compacts*
- *How Fatigue Affects Ductile Metal*
- *Plastics for Corrosion Resistance*

Adhesive Bonding Vs Riveting

Adhesive bonding of metals has been receiving more and more attention in the aircraft industry in particular, as well as in other fields. In aircraft assemblies, a component which lends itself most favorably to adhesive bonding is the flat sheet-stringer panel. An investigation of the relative merits of riveting and adhesive bonding panels of this type was carried out by the National Bureau of Standards under the auspices of the National Advisory Committee for Aeronautics.

In the report issued in June of this year by the NACA, L. Mordfin and I. E. Wilks detailed the methods of testing and the results derived. The tests were carried out on 21 sheet-stringer panels of 75S-T6 aluminum alloy having alclad sheets nominally 0.051 in. thick and stringers nominally 3½ in. apart. The specimens used were not identical since the features of each joining method require different attachment designs to gain the optimum advantage of the method. The specimens for the alternate fabrications employed the best practice to produce a panel for the same type of service.

No universal superiority of one type of construction over the other was found. Both types seem to show properties in the same general order of magnitude. The primary advantage of the adhesive bonded specimens is the increased sheet stability obtained. Inter-rivet buckling and stress concentrations near the rivet heads are eliminated. Some evidence indicates that the bonded specimens have greater shear strength than the riveted joints, but the authors point out that this condition will vary with the dimensions and fabrication techniques of the particular joint.

The results indicate that with proper design and fabrication cleavage may not be the primary factor governing the strength of bonded sheet-stringer panels. Also, the bonded joints, like the riveted ones, are strong enough to suffer almost no visible damage under high bending loads which eventually cause fracture of the webs of the stringer.

The primary disadvantage of adhesive bonding, according to the authors, is the lack of warning before failure in flat-end compression. When maximum load is reached, the bonded panels experienced almost complete destruction with no warning signs other than a few preliminary cracking noises. The failure of the riveted panels, on the other hand, is confined to local buckling of sheet and stringers between rivets near the midpoint of the panels.

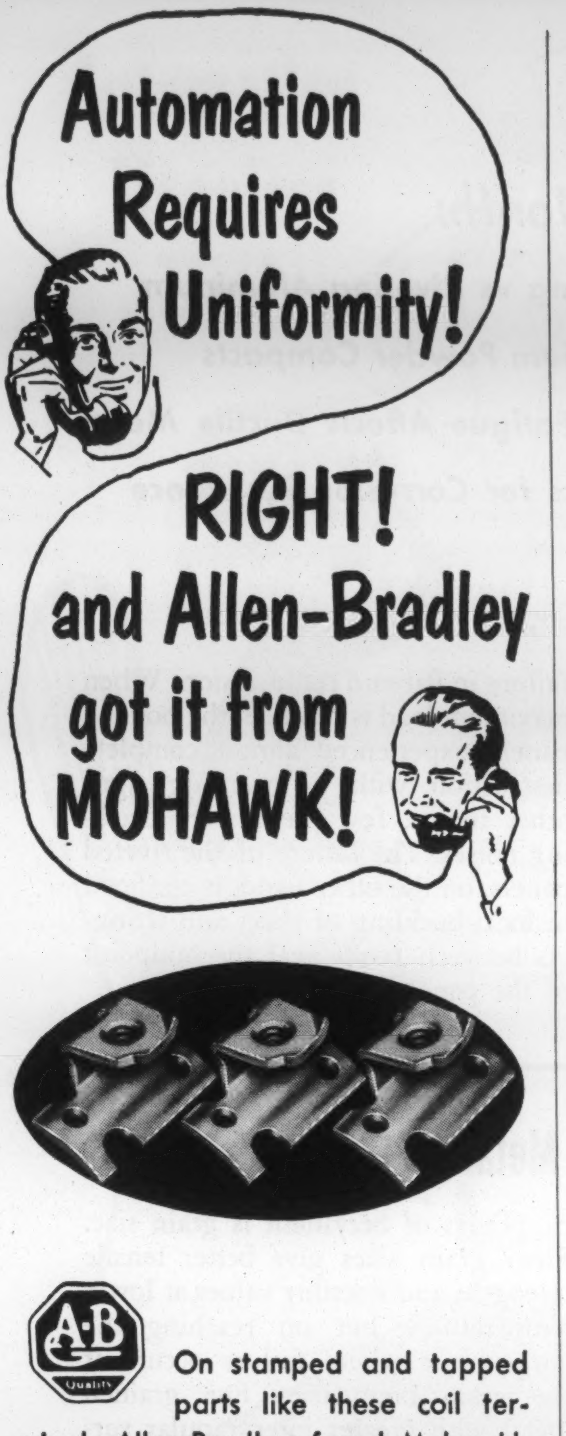
Properties of Beryllium Powder Metal

The most common form of beryllium fabricated by powder metallurgy, the vacuum hot pressed material, has low but significant ductility, intermediate strength, and generally isotropic mechanical properties. Extruded forms have high room temperature strength, and ductility values ranging up to 20% elongation, but are highly anisotropic. These facts are included in the report by W. W. Beaver and K. G. Wikle of the Brush Beryllium Co., on a survey of the mechanical properties of commercially pure beryllium fabricated by powder metallurgy. The work was carried out under the auspices of the U. S. Atomic Energy Commission, and reported in the May issue of the *Journal of Metals.*

Beryllium exhibits appreciable ductility in tension at temperatures above room temperature and in torsion at all temperatures. Vacuum hot pressed beryllium goes through a brittle to ductile transition at a temperature of 200 to 400 F. Tensile ductility increases up to 750 to 1000 F where a change from transcrystalline to intergranular failure occurs, after which the tensile ductility as well as tensile strength falls off rapidly.

According to the authors, the major variable affecting the mechanical properties of beryllium is grain size. Finer grain sizes give better tensile strengths and ductility values at lower temperatures, but on reaching the temperature where failure occurs at the grain boundaries fine grained metal with greater intergranular surface area shows less mechanical strength than the coarse grained metal. Since beryllium acquires a high degree of preferred orientation in the plastically deformed condition, the type and extent of fabrication has a pronounced effect on the mechanical properties of the metal.

Because of its improved ductility at temperatures above 600 F, fabrication operations such as extrusion, rolling, forging, and swaging are best carried out at temperatures from 600 to 2000 F. Beryllium has a low density, a high modulus, a relatively high melting point, and adequate strength at elevated temperatures indicating its use in the commercially pure state for special applications up to around 1000 F. The temperature range for optimum properties of the metal is 200 to 900 F. Where grain boundary characteristics can be improved to avoid intergranular failure, the temperature limits may be raised to around 1500, where the limiting factor becomes atmospheric corrosion.



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A-B Quality

On stamped and tapped parts like these coil terminals Allen-Bradley found Mohawk's guaranteed uniformity eliminated rejects, both of parts and finished coils. Since their usage is 200,000 per month, down-time could have been extremely costly.

But Mohawk not only maintained production and quality levels—they also were able to deliver the stamped, formed *and tapped* parts at a substantial saving over the usual cost of fabrication.

If you'd like to get small threaded stampings in large quantities with guaranteed uniformity—automatically—send blue prints or write to:

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MIDDLETOWN, CONN.

For more information, Circle No. 338

Contents Noted

Fatigue Effects . . .
Plastics . . .

Effect of Fatigue Loads on Cold-Worked Metals

The cause of fatigue failure in ductile metals has been associated, in the minds of many, with progressive strain-hardening in certain regions of the matrix of the alloy. Although this is true for initially unstrained metals results of some recent work indicate that the cold worked metals may soften gradually under action of fatigue loads. This is based on the postulate that stress cycles of a given type and amplitude should tend to produce a specific condition. In other words, no matter whether the material is initially soft or hard, under this stress cycling, the trend in hardness will be toward this specific work-hardened state. An initially soft metal will harden under this stress cycling until the final hardness level is attained, while a metal which has been initially cold-worked to a hardness higher than this final level will soften under the same cyclic stress.

These results were reported in a paper delivered before the Annual Meeting of the American Society for Testing Materials in June of this year, by N. H. Polakowski and A. Palchoudhuri. Their work included experiments with copper, nickel, aluminum, and three of their alloys, as well as a non-aging titanium-killed steel, first cold-drawn 20 to 40% to 0.2 in. in diameter and later subjected to alternating tension-compression fatigue stressing at frequencies of 5500 to 9500 cpm.

According to the authors, their work was not conclusive; however, the experiments did show a distinct over-all softening of cold-worked materials under fatigue loads. They suggest that in this case a fatigue fracture is originated by the gradual breakdown under cyclic strain of the high elastic properties acquired during initial cold-working. Consequently, plasticity increases rather than decreases. The fatigue crack then seems to be associated not with decreased ductility, but rather with the semiplastic condition developed by the action of the alternating strains.

How Plastics Aid the Chemical Industry

Though there are many ways in which the chemical resistance of plastics can be utilized in the chemical industry, perhaps the best way to introduce them in various uses is as emergency maintenance and repair materials. The ease with which plastics can be fabricated makes emergency repairs relatively simple. These observations are made by S. W. Shepard in a paper presented at the Annual Conference of the National Association of Corrosion Engineers, and published in the July issue of *Corrosion.* Also included in the paper are several case histories illustrating, first, the use of plastics as emergency materials and second, the need for more accurate non-destructive tests for reinforced plastics.

Polyester Aids Tank Repair

In 1952 when some stainless steels were difficult to get, a 17% chromium steel nitric acid storage tank failed in service. It is almost impossible to field repair this type of tank due to the need for heat treatment after welding, and there would have been a delay of several months in getting a replacement tank. Laboratory tests showed that a polyester resin had good resistance to the 60% nitric acid stored in the tank. In a few weeks time the tank was completely wrapped with a glass fiber reinforced polyester covering for a fraction of the cost of a new tank. The tank has been in service for over a year and a half and is reported to be in excellent condition.

Furan and Aluminum

About three years ago a materials selection problem arose in the construction of a mixing chamber which had to handle gases containing a mist of sulfuric acid, SO$_2$, SO$_3$ and air at 430 F. The structure had to be light in weight as it was to be used at the top of a stack handling the gases from a sulfuric acid absorption system. The structure was finally fabricated of aluminum, and covered with a glass re-

Contents Noted | Rubber-Mold Castings...

inforced furan resin. The unit has been in service for 3 years and is said to be in excellent condition in spite of the fact that inspection at the end of the first year revealed that the aluminum had been completely eaten away. The self-supported furan material was unaffected.

The Fluorocarbons

The fluorocarbons have given some excellent service in packing and gasketing applications. Teflon has been used successfully as an emergency baffle in molten guanidine hydrochloride operating at 400 F. The use of these materials in larger pieces of equipment is now awaiting successful lining and coating techniques.

Need for Tests Stressed

The author feels that there is now a substantial need in the field for good non-destructive tests to determine physical properties of reinforced plastics. He points out that conducting destructive physical property tests is both expensive and time consuming, and that it takes a multiplicity of tests to determine the change in physical properties over extended periods of time.

A case in point, cited by the author, is that of an old lead-lined bricklined steel alum evaporator. Maintenance costs had become high, and laboratory tests indicated that a glass reinforced polyester laminate had the resistance necessary for prolonged use in the digester. The original digester was replaced with one made of the polyester laminate. After 7 months of use, the evaporator started leaking, indicating that short time exposure tests evaluated by weight change and appearance can give misleading results.

Casting Metal in Rubber

A relatively inexpensive metal forming method has been developed for casting the low melting point (under 600 F) alloys in intricate shapes and to the dimensional accuracy necessary for such applications as costume jewelry. It is designed for relatively low production runs, which would not justify the costs of dies for die casting. As reported in the May issue of *Tin and Its Uses*, published in England by the Tin Research Institute, the process involves a small centrifugal casting machine and rubber

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★ **DESIGNING** Service . . analyzes existing designs from the blueprint. Submits full, comprehensive report to the customers engineering facilities. Aids the customer in arriving at a conclusion with the foundry for the best possible design, from both castable and usable views.

★ **ESTIMATING** Service . . provides accurate cost figures with every necessary step itemized. Submitted after mutual design problems are solved and quantity and initial delivery requirements are established.

★ **PRE-PRODUCTION** Service . . includes pattern expediting and construction in conformity with production requirements. to realize economies wherever plausible. Includes sample casting presentation in minimum time for formal approval.

★ **SCHEDULING** Service . . coordinates production with customers requirements. Includes accumulation service for full truck load, and methods such as palletizing for faster handling. All shipping facilities are available directly at the foundries.

★ **SPECIAL** Service . . available after consultation. Includes close tolerance castings, special heat treating, intensified inspection of critical areas, and other finishing requirements not considered standard procedure.

★ **FOLLOW-UP** Service . . carried out periodically during production and delivery, aids both foundry and customer production. Design revisions, greater efficiency, revised schedules, etc., stem from this customer service.

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Unitcast QUALITY STEEL CASTINGS

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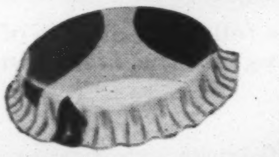
FROM 8 PER DAY...
TO 400 PER DAY!
(and no rejects)

Barrel finishing boosts die maker's production 5000%



This almost unbelievable production increase was made by Callahan Can Machine Co., Inc., makers of bottle cap dies, when they switched to the HONITE Barrel Finishing Method. Too, per-unit labor costs for finishing were cut by a phenomenal 99.8% !

Dies are used to stamp out painted bottle caps. The problem was to remove sharp edges so that paint on the cap flanks would not be scratched. Former method of hand stoning each die resulted in low production with many rejects because hand stoning did not effectively round off the edges.

A HONITE barrel finishing machine, using SUPER-HONITE chips and the recommended HONITE compound was installed. Production immediately jumped to several hundred pieces per day.

Dies came out perfectly uniform, quality was improved and the reject problem was eliminated completely!

METAL FINISH, INC., Newark, N.J., is the HONITE distributor servicing the Callahan Can Machine Co. Your HONITE distributor can help you increase production and cut costs, too. Call him today!

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Barrel Finishing Manual

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☐ Send me free copy of "3M Barrel Finishing" Manual
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COMPANY..
ADDRESS..
CITY........................ZONE.....STATE................
Type of product to be finished..............................

Made in U.S.A. by Minnesota Mining and Mfg. Co., St. Paul 6, Minn.-also makers of "Scotch" Brand Pressure-Sensitive Tapes, "Scotch" Sound Recording Tape, "Underseal" Rubberized Coating, "Scotchlite" Reflective Sheeting, "Safety-Walk" Non-slip Surfacing, "3M" Abrasives, "3M" Adhesives. General Export: 122 E. 42nd St., New York 17, N.Y. In Canada: London, Ont., Can.

3M

For more information, turn to Reader Service Card, Circle No. 399

molds. The rubber is vulcanized around the pattern to form the mold and the elasticity of the material allows the forming of quite intricate shapes with undercuts.

The alloys found most suitable for use are the tin base with additions of antimony and copper for increased strength and hardness. Cheaper alloys such as 60:40 tin-lead or even certain type metals may be used, but some of these alloys lack the fluidity of tin and will not reproduce sharp detail, and at higher temperatures the molds deteriorate more rapidly. Mold life when casting alloys with melting points below 600 F is said to be about 1000 cycles.

The dimensional accuracy is reported to be good in the plane of the mold, though dimensions perpendicular to the plane of the mold are very often reduced to below those of the pattern.

(Book Reports on page 174)

Coming in MATERIALS & METHODS

Watch for these important M & M Manuals to appear soon in MATERIALS & METHODS:

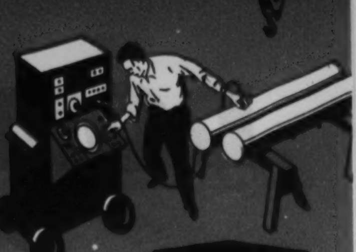
October—
Properties of Age Hardened Metals

November—
Adhesive Bonding of Metals

December—
Clad Metals—Types, Properties and Uses

For more information, Circle No. 525

Tool Steel Topics



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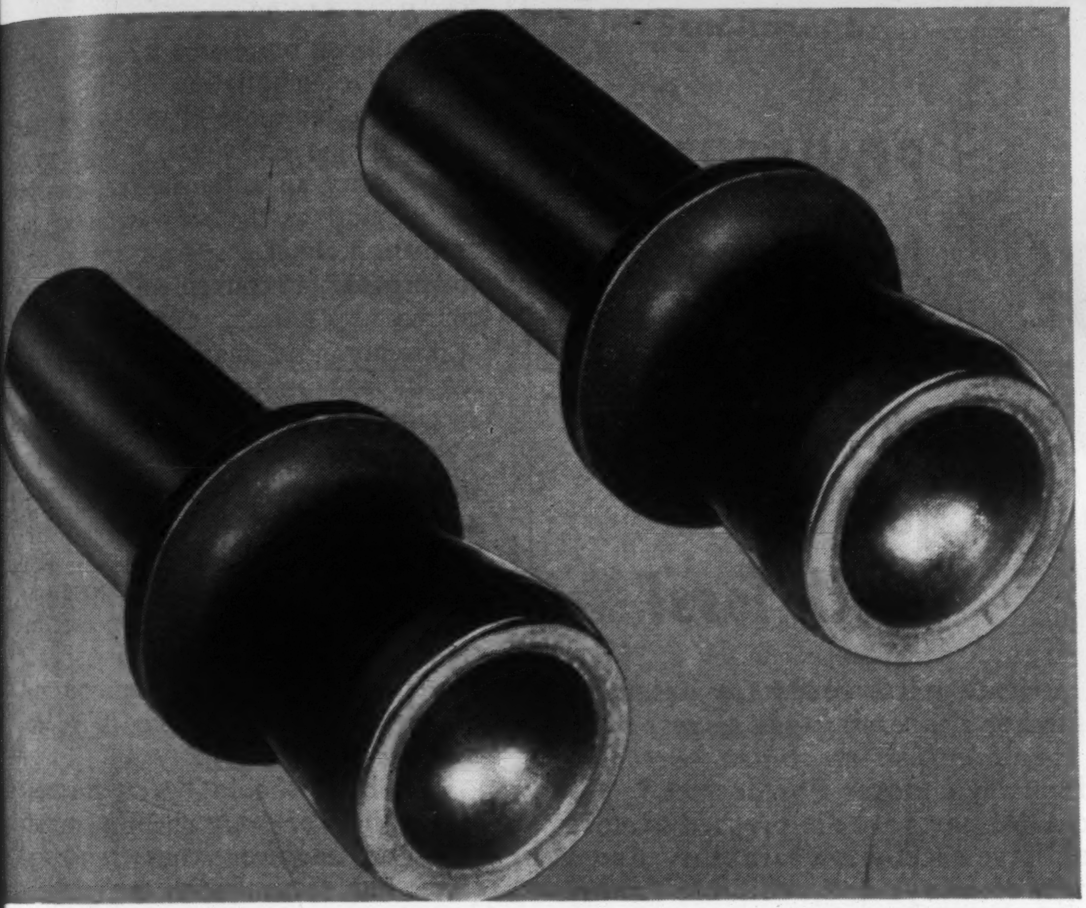


Boiler Shop Using Bearcat Rivet-Sets Ups Average Run from 300 to 2470

The mechanical department of a large boiler shop had trouble driving more than 300 hot rivets, using standard rivet-sets. Once that mark had been reached, the sets would crack or spall. Sometimes recupping saved the day, but oftener than not the sets had to be replaced.

We were sure they could get longer runs with rivet-sets of Bearcat tool steel. The management gave Bearcat a trial, and put six sets to work after a heat-treatment cycle consisting of preheating at 1200F, air-quenching at 1750, and tempering at 550.

The results were even better than expected. The average run increased from 300 to 2470 before recupping was required. Not only that, but the recupping was accomplished without heat-treatment, which of course is a frequent source of trouble with rivet-sets of carbon tool steel.

Bearcat is an ideal tool steel for the manufacture of rivet-sets because of its superior shock-resistance. It is also well suited for uses where hot-work properties and easy machining are essential.

BEARCAT'S BIG FEATURES

1. Super shock-resistance
2. Deep-hardening . . . in air
3. Machines easily (Brinell 197 max)
4. Low distortion in heat-treatment
5. Good hot-work properties
6. Easily carburized for long wear

Typical Analysis

C	Mn	Si	Cr	Mo
0.50	0.70	0.25	3.25	1.40

In addition to being used for rivet-sets, Bearcat is ideal for such hot- and cold-shock applications as chisels, punches, hot headers and gripper dies. It has many other uses, too — master hobs, engraving dies, die-casting dies, and short-run dies used in cold-forming, blanking and bending.

You'll be well pleased with the service life obtained with Bearcat. We stock Bearcat in our mill depot. Or you can obtain a supply through your local Bethlehem tool steel distributor.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Use Care When Hardening Hot-Work Tools

Although hot-work tools can be hardened to Rockwell C-56-60, there are hardly any applications where such hardness is beneficial. The majority of hot-work tools are used in a hardness range of C-41-44, or C-46-49. On new hot-work applications, a common mistake is to heat-treat to a hardness level which is too high for the application, with the result that rapid heat checking or breakage occurs.

For example, put tools of our Hot Work 8 analysis to work at C-55 or higher, and chances are, they will fail prematurely. Yet these same tools, used at Rockwell C-52 or lower, will give outstanding service.

On every hot-work application the best hardness level must be determined by experience. There's always a compromise involved, as the highest hardness is best for wear-resistance, and the lowest hardness is more resistant to heat-checks. Our suggestion? To be sure of maximum service, don't overharden hot-work tools.

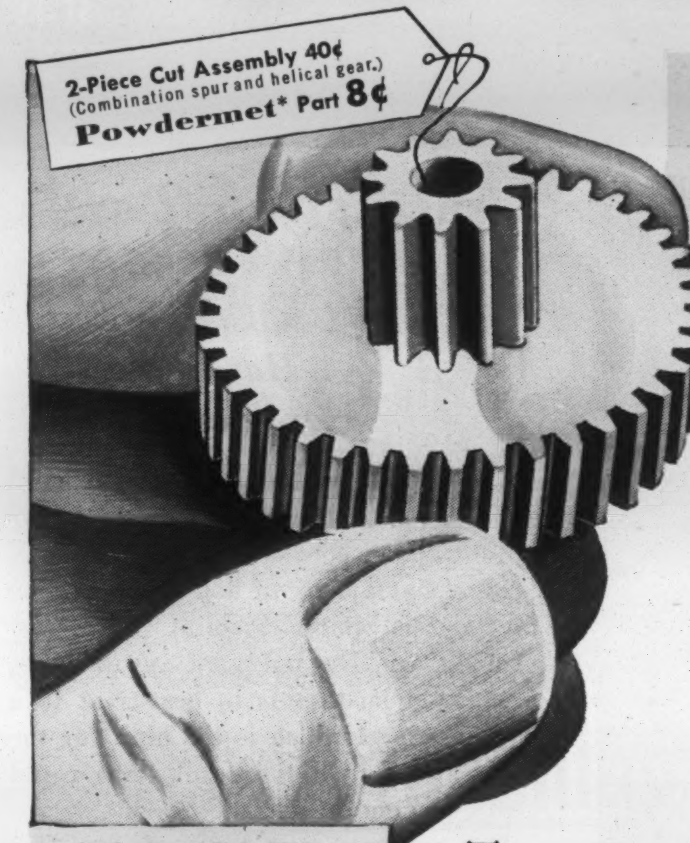
IT'S A-H5 FOR LONG PRODUCTION RUNS

This high-production die, made of A-H5, blanks and punches sheet steel of 0.180-in. thickness. A-H5 makes possible long production runs between grinds. It holds a durable cutting edge, and resists distortion in heat-treatment.

For more information, turn to Reader Service Card, Circle No. 409

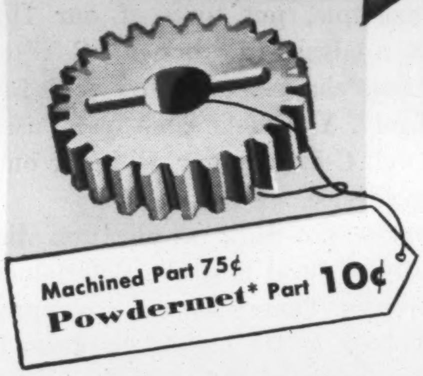
DON'T CUT PARTS

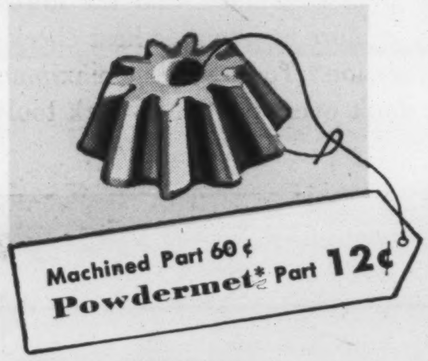
...Cut Costs!

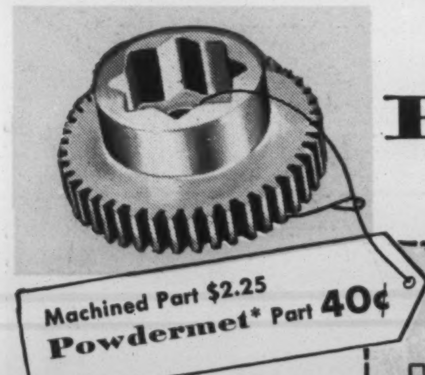


Why pour money into expensive machining operations?

POWDERED METAL PARTS can do the job for *much less!*







Tough, intricate parts ready for assembly without further processing—at *savings of up to 600% over identical machined parts!* No wonder industry chooses Powdermet.*

Low-cost PM parts are die-pressed to close tolerances, have excellent wearability, and a wide range of alloys are available—many exceeding the tensile strengths of mild steel. Through controlled porosity and electrical permeability, many special properties are achieved . . . such as oil-impregnation for life-time self-lubrication. That's why Powdermet* parts are often the *best parts possible* for gears, bearings, filters, etc.

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For more information, turn to Reader Service Card, Circle No. 404

Contents Noted

Books

Rare Metals Handbook. *Edited by Clifford A. Hampel. Reinhold Publishing Corp., New York 22, N.Y., 1954. Cloth 6 by 9 in. 657 pp. Price $12.00.*

This book represents the first comprehensive compilation of the available data on more than 35 of the less common elements. It was written to offer an authoritative, concise background to the man seeking information about a specific metal and to provide a convenient reference source.

Twenty nine chapters, each written by one or more experts on the specific element under discussion cover occurrence, production, statistics, economics, extraction, physical and chemical properties, fabrication techniques, and applications. Selected references are given for more detailed study. The list of metals included is admittedly arbitrary, but it covers most of the less common materials about which there is an increasing interest.

This book should be on the reference shelf of every chemist, metallurgist or engineer whose work requires him to deal with the production or application of any of the newer metals.

Adhesive Bonding of Metals. *George Epstein. Reinhold Publishing Corp., New York, N.Y., 1954. Cloth, 4½ by 7 in. 218 pp. Price $2.95*

This book, the second in the Reinhold Pilot Book series, is designed to give the engineer, faced with the problem of joining two materials, sufficient information to enable him to determine whether an adhesive bonded joint would be advantageous.

Chapters are devoted to industrial adhesives for metal fabrication, basic materials for adhesives, formulation, high temperature adhesives, design and testing of adhesive joints, bonding techniques and adhesives for metals in sandwich constructions.

This book will be particularly useful to the engineer or designer interested in a brief but thorough discussion of the possibilities of joining metals with adhesives.

Forming and Bending Kaiser Aluminum. *Kaiser Aluminum & Chemical Sales, Inc., Chicago 11, Ill., 1954. Cloth, 6 by 9 in. 260 pp.*

The information presented here has a threefold purpose: to offer en-

Contents Noted

Books

gineers specific data on aluminum characteristics which may be used from a design standpoint; to present management with comparative material on different types of forming equipment, and to outline in detail, practical forming and bending procedures.

Manual for Plastic Welding—Volume II Polyethylene. *G. Haim and J. A. Neumann. Industrial Publishing Co., Cleveland, Ohio, 1954. Cloth, 9 by 6 in. 128 pp. Price $6.00.*

This manual deals with the gas welding of plastics and the applications of gas welding. It was written for the practical man and is designed to give him all the information necessary to become efficient in plastics welding. Volume II discusses the welding of polyethylene.

Several chapters are devoted to a discussion of the welding equipment and the welding process; the remainder of the book is devoted to polyethylene with chapters on development, commercial forms, suitable types of welds, general rules for working, the lining of tanks with polyethylene, pipe lines and industrial applications.

Metal Statistics 1954. *American Metal Market, New York, N.Y., 1954. Cloth, 4 by 6 in. 848 pp. Price $3.00.*

The 47th annual edition of this work contains the same general assortment of statistical information on ferrous and nonferrous metals, and various economic subjects as was presented in previous volumes. Domestic statistics, however, have been slightly augmented in this issue by the addition of tables showing a new index of steel production introduced by the American Iron and Steel Institute, and by new tables showing tool steel production, world production of cadmium, and monthly average prices of zinc-base die casting alloy ingot.

Minerals for the Chemical and Allied Industries. *Sydney J. Johnstone. John Wiley & Sons Inc., New York, N.Y., 1954. Cloth 6 by 9 in. 692 pp. Price $11.50*

The object of this book is to present in a concise form essential information on those mineral and metals which are finding increased use in the chemical and allied industries;

(Continued on page 176)

For more information, Circle No. 49 ➤

MUELLER BRASS CO. forgings help insure dependable operation of aircraft pressure warning instruments

A specially designed housing, accurately forged to customer specifications by Mueller Brass Co., seals in the diaphragm of the pressure warning unit manufactured by Eclipse-Pioneer Division of Bendix Aviation Corporation in Teterboro, New Jersey. The unit, designed for installation in fuel, oil, water or alcohol lines of modern aircraft is a highly sensitive instrument that instantly warns the pilot or flight engineer of any unusually high or low fluid pressures.

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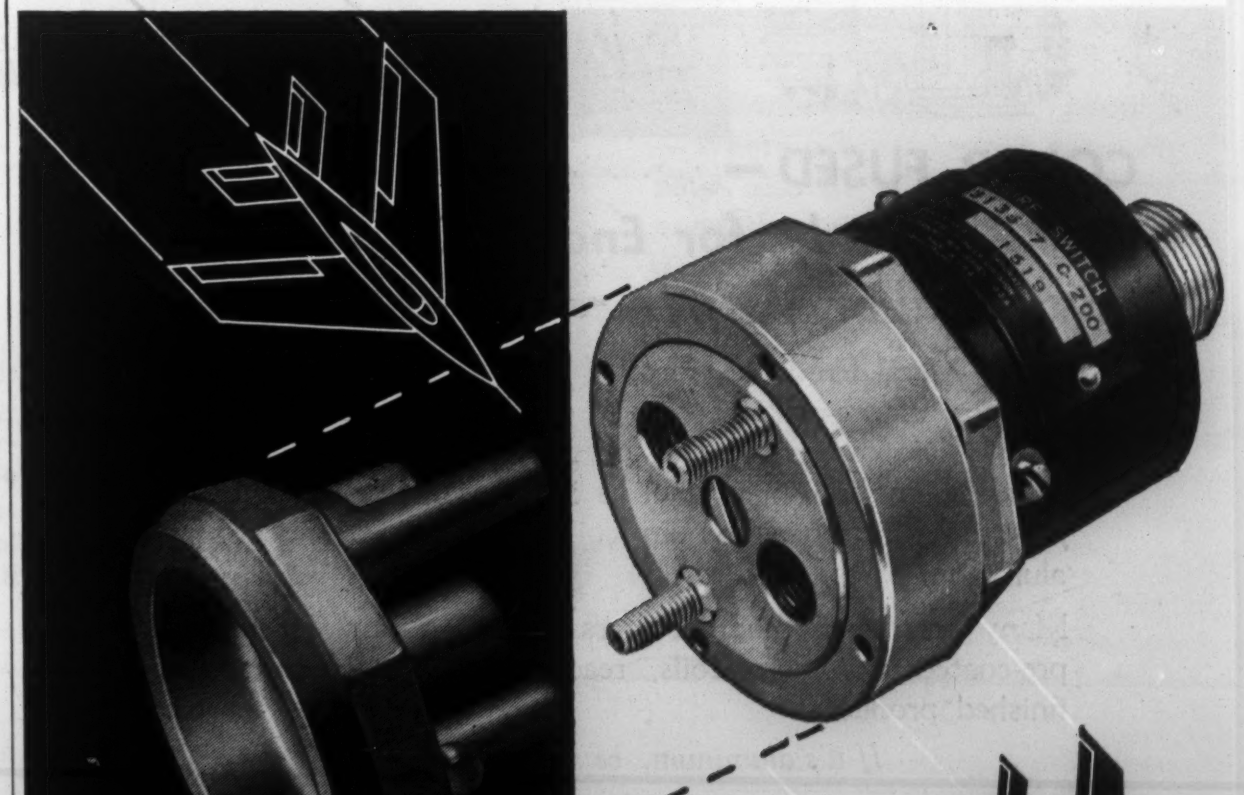

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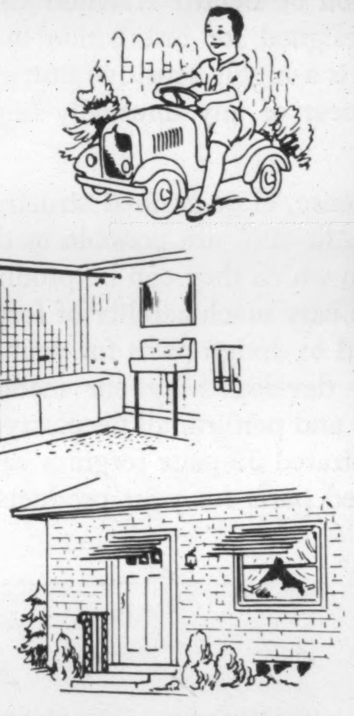

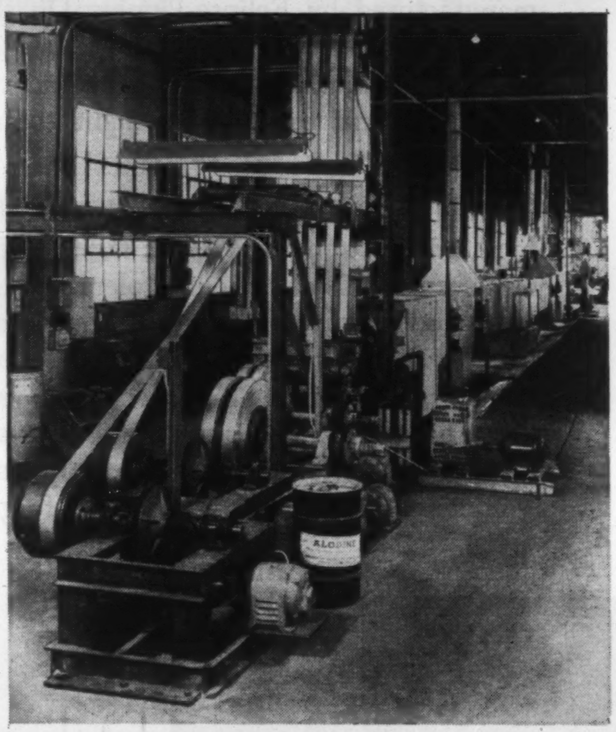

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such as those producing ceramic materials, refractories, building materials, paints, etc. Covered here are the properties of these minerals and metals, their sources of supply, processing and metallurgy, and uses with special reference to specifications laid down for their uses in particular industries.

Essentials of Strength of Materials. *Torquato J. Pisani. D. Van Nostrand Co., Inc., New York 3, N.Y., 1954. Cloth, 6 by 9 in. 245 pp. Price $3.60.*

This second edition gives a brief systematic presentation of elementary mechanics and strength of materials designed especially for use in technical high schools, technical institutes, and vocational schools. The contents have been expanded and developed over a long period of use in the teaching of the strength of materials. In this edition, the chapter on Shafts has been enlarged to include combined stresses caused by both bending and torsion, and elastic deflection or torsional deflection.

Bibliography on Filing, Classification, and Indexing Systems for Engineering Offices and Libraries. *Engineering Societies Library, New York, N.Y., 1954. Paper Mimeographed. 18 pp. Price $2.00.*

This is a selected list of references prepared for engineers and librarians concerned with organizing their own files. References are to articles, books, and pamphlets on filing, classification and indexing, lists of subject headings, and hand-sorted punched-card systems. Some of the listed items are general, others relate to specific subject fields.

Manual of Porcelain Enamel Processing. Volume I Spraying. *Porcelain Enamel Institute, Washington 6, D.C., 1954. Paper, 6 by 9 in. 45 pp. Price $1.00.*

The work of a special sub-committee on Spraying appointed by the Institute's active Process Development Committee, this booklet covers every phase of spraying porcelain enamel upon the base metal, from the development of the gun to the atomization; the effect of mal-practices in spraying, and the performance of the equipment itself. Also covered are the different methods of obtaining atomization, such as compressed air, steam, hydraulic pressure, electrostatic and centrifugal forces.

(Continued on page 178)

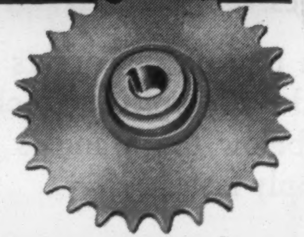
Better Brazing

that actually costs less!

Saves $25,000 ANNUALLY!

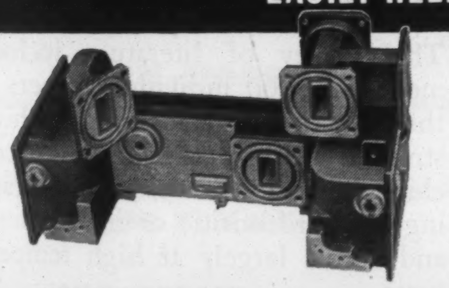
SAE-1010 steel bicycle forks are brass brazed at the rate of 280 forks per hour in a mechanized Ajax salt bath unit that brazes, washes and dries the forks automatically. Production has been increased 270%.

THE BRAZING IS PRACTICALLY Free!



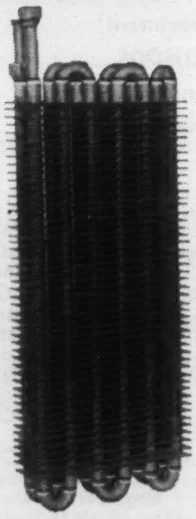
Brazing and carburizing of this SAE-1010 steel sprocket assembly are completed simultaneously with one heating of the work in an Ajax salt bath carburizing furnace. Hub is brass-brazed to sprocket body . . . The assembly is file hard after oil quenching.

Tolerances OF 0.002″ EASILY HELD!



Micro-wave components, like this aluminum wave guide, can be aluminum dip-brazed, holding tolerances of 0.002″. Fast brazing time and uniform bath temperatures (guaranteed within 5°F of control point) give high production and uniform results.

LABOR Costs Cut 96%!



Copper heat exchangers are silver brazed in only 1¼ minutes in a 1500°F bath. Return bends on each end are brazed simply by immersing only that portion of the assembly. Former hand torch brazing required 30 minutes.

Any material that can be brazed at all can be brazed in an Ajax Electric Salt Bath Furnace — *much faster, better and usually at lower cost.* First cost of equipment is only ½ to ⅕ that of any other production brazing system. But that's only part of the story:

Brass Brazing of Steel Parts — Brass brazed joints are fully as strong as those of copper! This money-saving method is possible *only* with a salt bath furnace, thanks to its greater heating speed — so fast that no dezincification of the brazing metal occurs. Brass brazing at 1700°F compares with 2050°F for copper. The lower temperature greatly reduces grain growth and distortion of the steel. Operating costs are less.

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Simultaneous operations possible — Where a brass brazed assembly must also be carburized or hardened, the entire job can be done in a single heating operation at 1700°F. The brazing is practically free!

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Contents Noted

Books

The Properties of Tin. *Tin Research Institute, Inc. Columbus 1, Ohio. 1954. Paper, 6 by 9 in. 55 pp. Free of Charge.*

This is a completely revised edition of the book published originally in 1934. The new edition presents the atomic, nuclear, physical, physico-chemical and metallurgical data concerning pure tin. Wherever possible, one recommended value is given for a property instead of listing alternate values. Division of data are: atomic and nuclear properties, line spectra, x-ray data, crystallography, optical properties, electrical and magnetic properties, thermal properties, mechanical properties. Properties on tin alloys are not included since they are covered in a separate publication of the Institute.

Reports

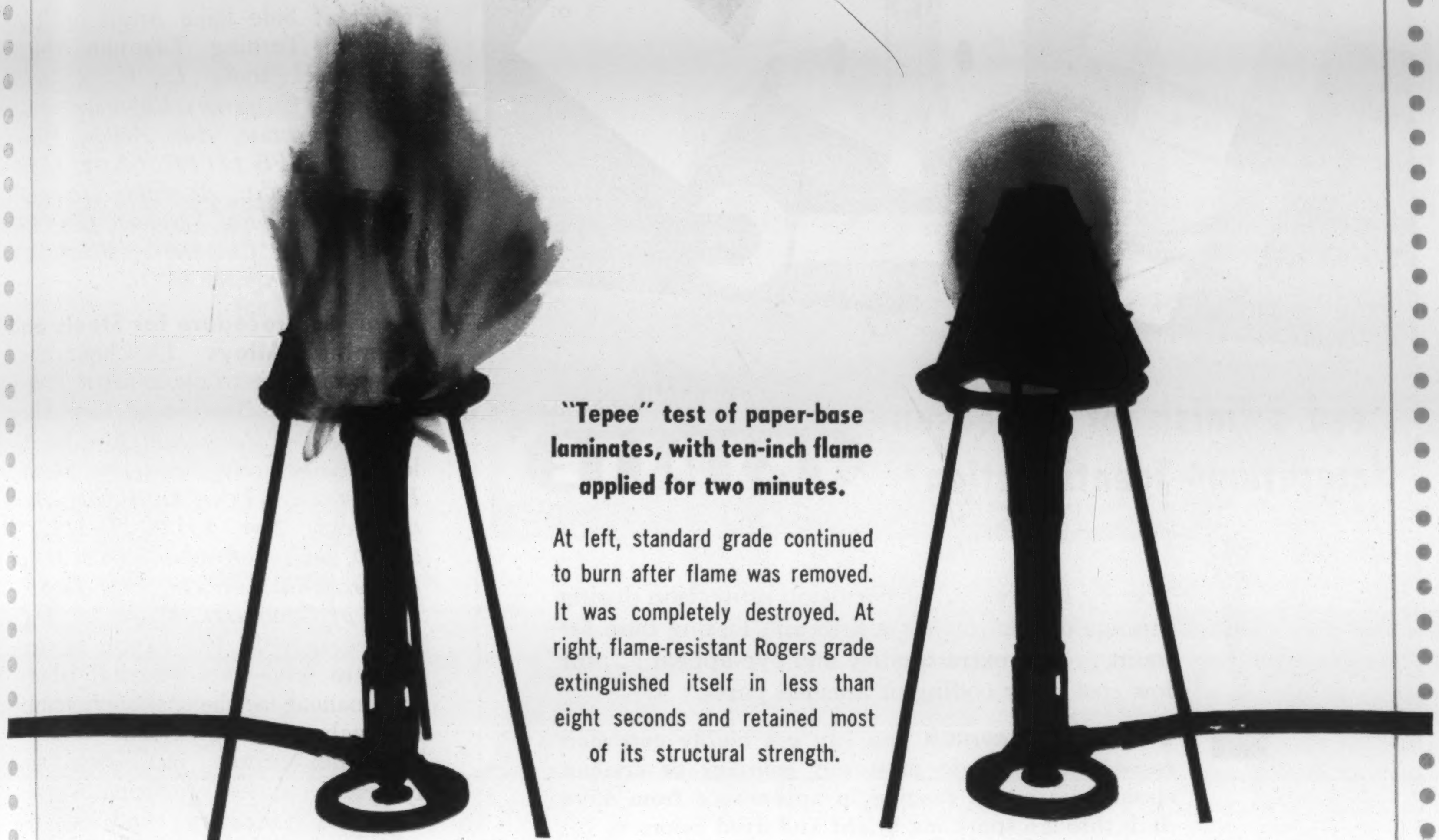
Weld Metal Cracking Literature Survey on Weld-Metal Cracking. *Wright Air Development Center. PB 111285, 212 pp. Available from U.S. Department of Commerce, Business and Defense Services Administration, Attn. Office of Technical Services, Wash. 25, D.C. $3.00.* Compiled by Baettelle Memorial Institute, a guide to future experimental work. This survey of literature includes more than 800 individual papers on the causes of cracking in high-strength weld metal. The report concludes that most weld-metal cracking is interdendritic or intergranular and occurs largely at high temperatures.

Machining Titanium Cutting Speed vs Tool Life when Shaping Titanium with High-Speed Steel Tools *L. V. Colwell and R. E. McKee, Michigan University, Engineering Research Institute, Ann Arbor, Mich., Jan. 1953. PB 111299, 21 pp, photographs, drawing, graphs, table. Available from Office of Technical Services, U.S. Department of Commerce, Wash. 25, D.C. Mimeograph $1.00.*

Effect of Size of Cut on Tool Life in Turning Titanium *L. V. Colwell, Michigan University, Engineering Research Institute, Ann Arbor, Mich., Jan. 1953. PB 111298, 56 pp, graphs, tables. Available from Office of Technical Services, U.S. Department of Commerce, Wash. 25, D.C. Mimeograph $1.25.*

(Continued on page 180)

another ROGERS innovation



"Tepee" test of paper-base laminates, with ten-inch flame applied for two minutes.

At left, standard grade continued to burn after flame was removed. It was completely destroyed. At right, flame-resistant Rogers grade extinguished itself in less than eight seconds and retained most of its structural strength.

WORK-HORSE MATERIALS MADE FLAME-RESISTANT

BY WORK-HORSE, we mean our paper-base laminates, which are now available with exceptional flame-resistant qualities. The main purpose of these materials is to reduce costs in applications that now require glass-base laminates.

We have also added flame-retardant properties to our DUROID 800, a fibrous insulating material, listed by Underwriters' Laboratories as suitable for the sole support of current carrying parts. DUROID 800 is also self-extinguishing, but will not withstand as severe burning as our flame-resistant laminates.

Since industry-wide specifications for flame-resistant or flame-retardant materials do not exist, each of these Rogers materials should be assessed in terms of your application. Complete data are available, and we will be glad to supply samples for your own testing purposes.

Please write Dept. M, Rogers Corporation, Rogers, Connecticut.

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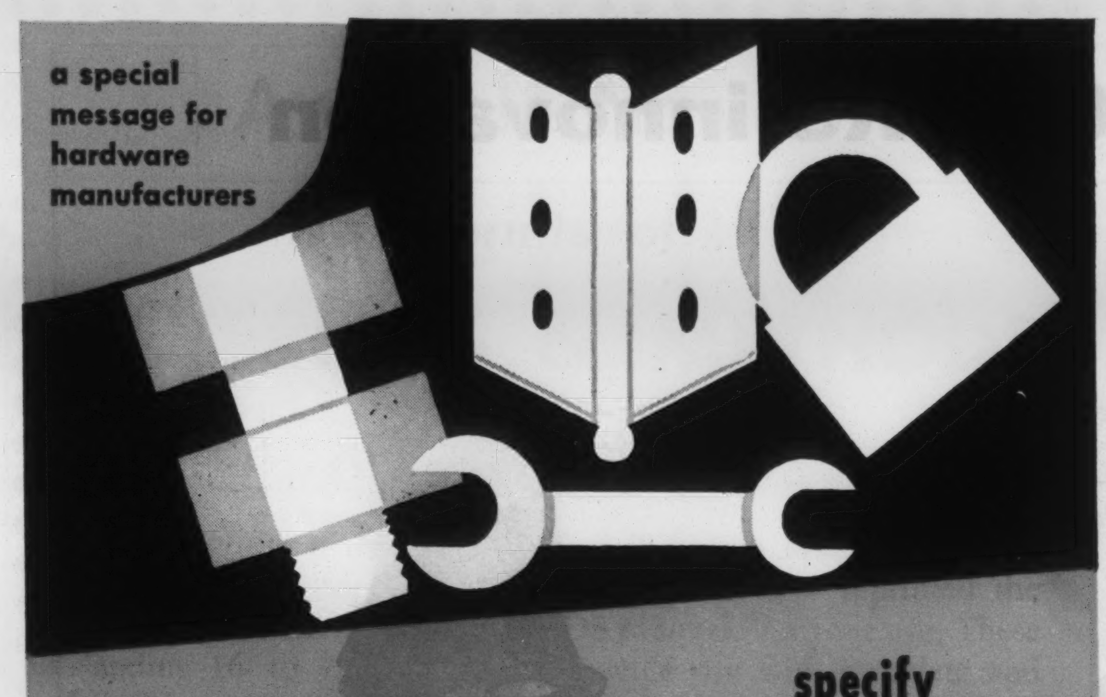
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Contents Noted

Reports

Effect of Side Rake Angle on Tool Life in Turning Titanium (high-speed-steel tools *L. V. Colwell, Michigan University, Engineering Research Institute, Ann Arbor, Mich., Jan. 1953. PB 111297, 62 pp, photographs, graphs. Available from Office of Technical Services, U.S. Department of Commerce, Wash. 25, D.C. Mimeograph $1.50.*

Analysis Procedure for Steels and Aluminum Alloys Development of Composite Spectrophotometric Procedures for the Analysis of Low-Alloy Steels and of Aluminum and Its Alloys. *Gilbert H. Ayres and Stanley H. Simonsen, Texas University, Austin, Texas, Nov. 1952. PB 111287, 68 pp, tables. Available from Office of Technical Services, U.S. Department of Commerce, Wash. 25, D.C. Mimeograph $1.50.* Report is compiled to serve as a practical laboratory manual for the spectrophotometric analyses in low-alloy steels for chromium, copper, manganese, molybdenum, nickel, phosphorus, silicon, and vanadium; and for the analyses in aluminum and its alloys of chromium, copper, iron, manganese, molybdenum, nickel, titanium, and vanadium.

Cobalt-Base Alloy Effect of Heat Treatment Upon the Microstructure and Hardness of a Wrought Cobalt-Base Alloy Stellite 21 (AMS 5385). *F. J. Clauss and J. W. Weeton, U. S. National Advisory Committee for Aeronautics, Mar. 1954. PB 113535, 26 pp, photograph, graphs. Available from National Advisory Committee for Aeronautics, 1724 "F" St., N. W., Wash. 25, D. C.* A period of 72 hr at 2250 F was found to be sufficient for effective solution treatment for this alloy. A maximum hardness Rc 42 was developed by aging 72 hr at 1400 to 1500 F as compared to Rc 20 to 22 for the solution-treated condition. Over-aging or softening occurred within 72 hr at 1750 F and above for aging, and 1950 F for isothermal transformation.

Relation of Microstructure to High Temperature Properties of a Wrought Cobalt-Base Alloy, Stellite 21 (AMS 5385). *F. J. Clauss and J. W. Weeton, U. S. National Advisory Committee for Aeronautics, Mar. 1954. PB 113578, 49 pp, photographs, graphs, tables. Available from National Advisory Committee for Aero-*

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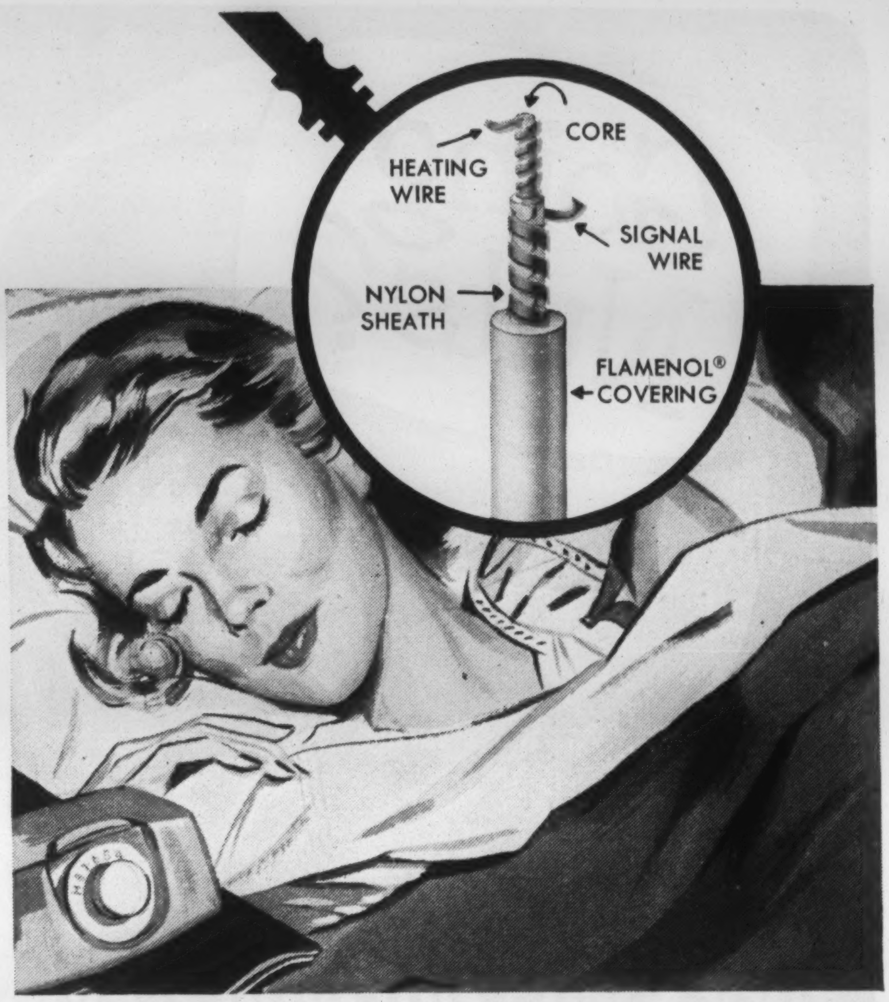

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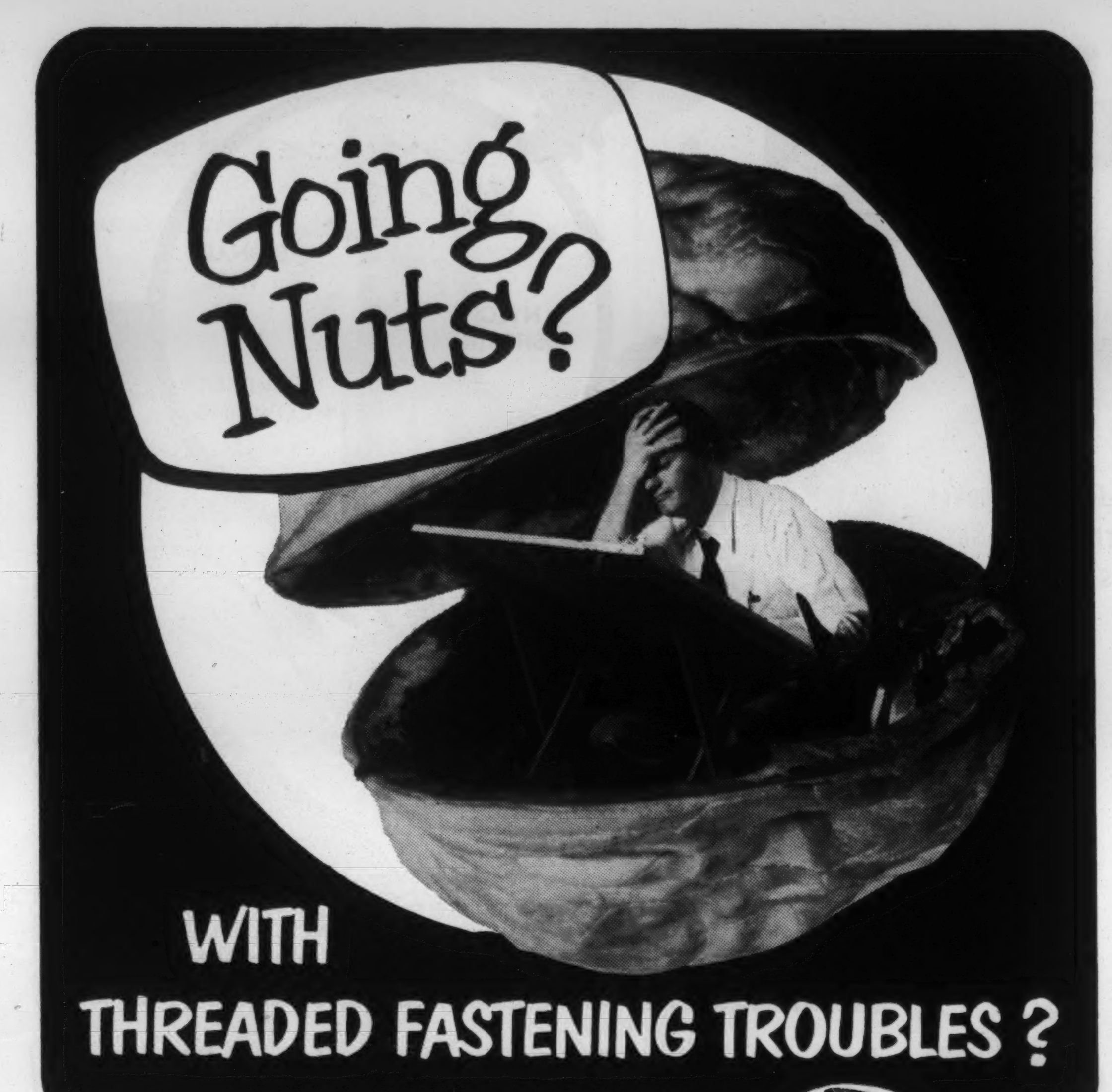
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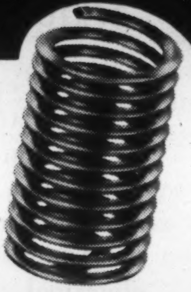

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nautics, 1724 "F" St., N. W., Wash. 25, D. C. Results obtained in this investigation lead to conclusions that are believed to have general significance in the heat treatment of other high-temperature alloys. The alloy was found to respond to solution treatment and also isothermal and aging heat treatments to form pearlitic and Widmanstätten structures as well as scattered precipitates.

Flash Welding Aluminum Fundamental Investigation of the Flash Welding of Aluminum Alloys. *Rensselaer Polytechnic Institute, Department of Metallurgical Engineering, Troy, N. Y., Mar. 1948. PB 109819, 114 pp, photographs, graphs, tables. Available from Library of Congress, Publication Board Project, Wash. 25, D. C. Microfilm $4.75, Photostat $15.00.* Report includes details of alloys studied and temperature distribution.

Hydrogen in Steel Further Studies of the Mechanism by Which Hydrogen Enters Metals During Chemical and Electrochemical Processing. *L. D. McGraw, W. E. Ditmars, C. A. Snavely and C. L. Faust, U. S. National Advisory Committee for Aeronautics, Mar. 1954. PB 113537, 38 pp, diagrams, graphs, tables. Available from National Advisory Committee for Aeronautics, 1724 "F" St., N. W., Wash. 25, D. C.* Appendix A is comprised of evidence taken from recently published literature which supports the proposed hydrogen-entry mechanism. Appendix B includes results of experiments on effect of hydrogen content on bend angle for steel specimens.

Phase Diagrams: Titanium Alloys Phase Diagrams of the Titanium-Aluminum, Titanium-Chromium-Iron and Titanium-Oxygen Alloy Systems. *R. J. Van Thyne, E. S. Bumps, H. D. Kessler, M. Hansen, Armour Research Foundation, Chicago, Ill., Dec. 1952. PB 111327, 94 pp, photographs, diagrams, graphs, tables. Available from Office of Technical Services, U. S. Department of Commerce, Wash. 25, D. C. $2.00.* Partial phase diagrams are presented for these systems, all studies being completed except for the titanium-chromium-iron system which requires further confirmatory work in certain areas.

(Continued on page 184)

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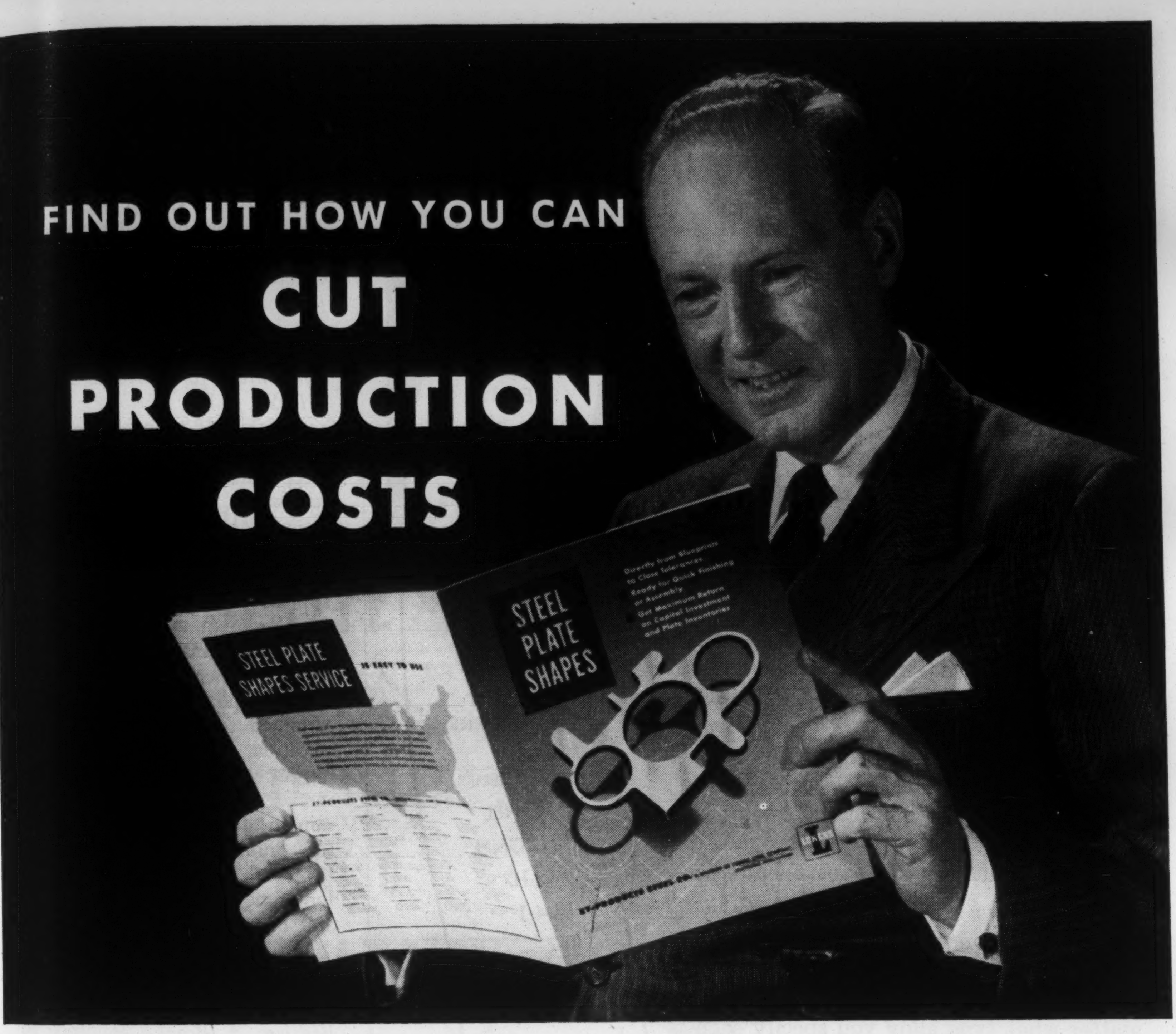

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*MONEL
*INCONEL
ACI-H7
18-4-1
IIB2
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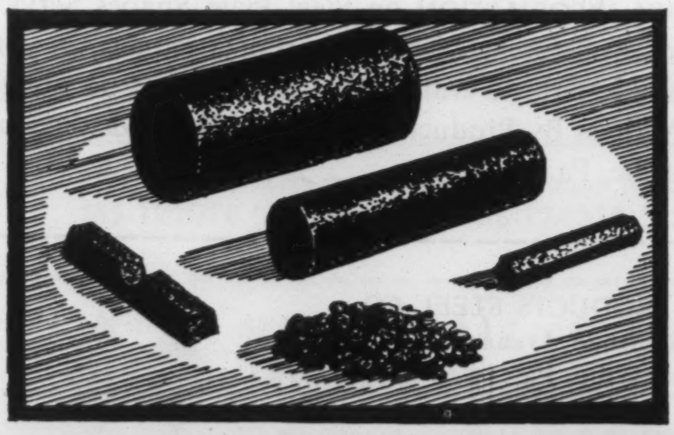

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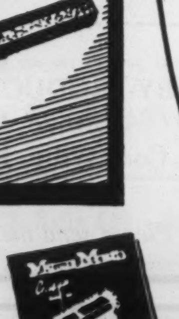

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Contents Noted

Reports

Rupture and Creep of Aluminum Time-Temperature Parameters and An Application to Rupture and Creep of Aluminum Alloys. *George J. Heimerl, June 1954. NACA TN 3195, 35pp, diagrams, table. Available from the National Advisory Committee for Aeronautics, 1512 "H" St., N.W., Wash. 25, D.C.* The application of time-temperature parameters to stress-strain, rupture, and creep data for metals and alloys is reviewed. Some comparisons are made of theoretical and experimental parameters. A parameter based upon rate-process theory was successfully applied to rupture and creep data for aluminum and various aluminum alloys. The value of the constant in the parameter, which provided the best correlation of the data, was determined for each material and application. Master curves of stress against the parameter which summarize extensive data on the aluminum alloys are presented for rupture, minimum creep rate, and time to 1 or 2% strain. Predictions of long-time life from short-time data are shown to be possible.

An Investigation of the Creep Lifetime of 75S-T6 Aluminum-Alloy Columns. *Eldon E. Mathauser and William A. Brooks, Jr., July 1954. NACA TN 3204, 28 pp, diagrams, photographs, table. Available from the National Advisory Committee for Aeronautics, 1512 "H" St., N.W., Wash. 25, D.C.* The results of short-time elevated-temperature creep tests of 75S-T6 aluminum-alloy columns are presented and examined with the objective of obtaining procedures for predicting column lifetime. Semi-empirical lifetime curves are obtained with the aid of a previously published column creep theory and are used for deriving column curves. A study is made of the effects of variations of stress and out-of-straightness on column lifetime. Small variations in out-of-straightness have been found to be of little practical significance, whereas small stress variations change the column lifetime considerably. Plots that do not explicitly include out-of-straightness are presented and may be satisfactory for predicting column lifetime for design purposes.

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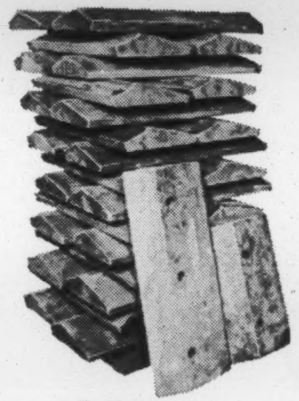

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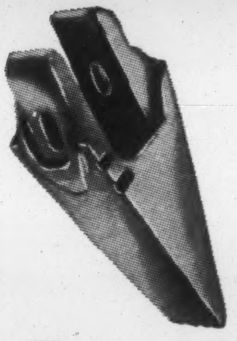
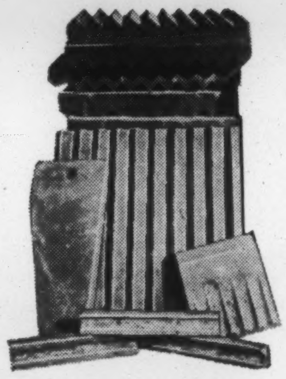


Dipper
Teeth



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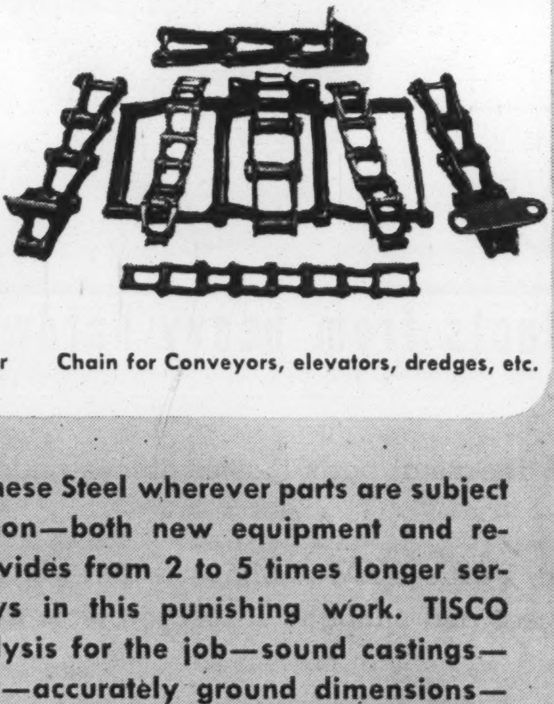

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mers. *National Bureau of Standards, 1954. PB 113550, 23 pp, graphs. Available from Library of Congress, Publication Board Project, Wash 25, D.C. Microfilm $2.25, Photostat $4.00.* Structural considerations of crystallization in butadiene polymers and copolymers and conditions under which such crystallization may be observed are outlined. It is concluded that crystallization is not observed if the polymerization temperature is above 60 C, and that 2 to 6% of bound styrene inhibits crystallization completely at polymerization temperatures of 50 C. At 5 C, the limit is about 15 to 18% bound styrene content. At –40 C, (the lowest polymerization temperature normally utilized) the limit is at about 30% bound styrene.

Protective Paints Alkyd Resins for Vinyl Finishes. *Naval Research Laboratory, 1954. PB 111369, 35 pp. tables, charts. Available Office of Technical Services, U.S. Department of Commerce, Wash 25, D.C. $.50.* Salt-spray tests designed to give the Navy better topside ship paints reveal that vinyl-alkyd combinations in paint formulations show vast improvement over alkyds used alone. Several series of alkyd resins were prepared, including glycerol, pentaerythritol, glycerolsorbitol, and mixed polyhydric alcohol. Of the glycerol products, a 30% phthalic anhydride alkyd showed the most resistanse to salt spray. Paints prepared from these resins used the standard matrix, Specification Mil-P-15936, as a base. Preparation of the resins, paints and test panels is described in detail. Test results for each series are discussed and portrayed graphically. This report covers the salt-spray portion of a broad program of outdoor exposure tests.

Titanium Proceedings of the Symposium on Machining and Grinding of Titanium. *1953. PB 111375, 167 pp, graphs, charts, photographs. Available from Office of Technical Services, U.S. Department of Commerce, Wash. 25, D.C. $2.50.* Report combines nine technical papers delivered at the Symposium held in Mar. 1953 at the Watertown Arsenal, Watertown, Mass. Subjects include the machining of titanium, internal and external grinding of titanium

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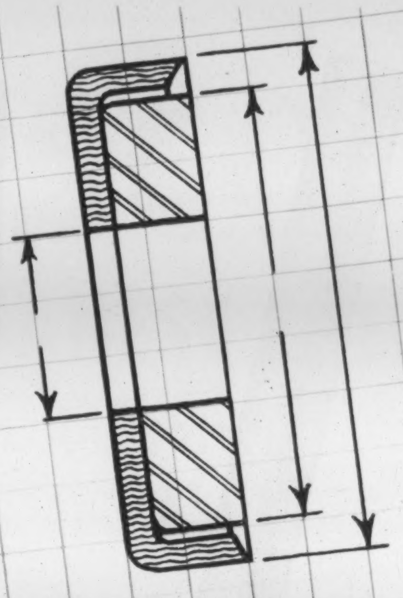

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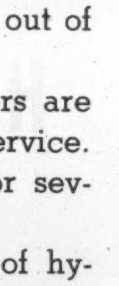

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Contents Noted

Reports

and its alloys, temperatures during machining, titanium alloy powders and chip formation. The papers are graphically illustrated and discussions are transcribed.

Low-Temperature Mechanical Properties, Including Fatigue, of Titanium-Base Alloys RC-130 B and Ti-150-A. *Wright Air Development Center, 1952. PB 112768, 41 pp, photographs, diagrams, graphs, tables. Available from Library of Congress, Publication Board Project, Wash. 25, D.C. Microfilm $2.50, Photostat $6.25.* The effects of low temperature on the mechanical properties of two commercially available high-strength titanium-base alloys are compared. Tests included tensile strength, fatigue, hardness, impact, and thermal expansion, at temperatures ranging from 25 to −253 C. One alloy showed an unusually high room temperature fatigue strength of 110,000 psi, compared to 84,000 psi for the other. Both showed relatively low impact strength. Thermal expansion coefficient decreased for both alloys as the temperature was lowered.

Fatigue Predictions Review of Previous Work on Short-Time Tests for Predicting Fatigue Properties of Materials. *Wright Air Development Center, 1953. PB 111374, 65 pp. Available from Office of Technical Services, U.S. Department of Commerce, Wash. 25, D.C. $1.25.* Methods of rapidly determining fatigue properties of materials without completing the usual S-N fatigue diagram are reviewed. Short-time fatigue testing methods are classified and their advantages and applicabilities discussed. Classifications are derived from the relationship of fatigue properties to static properties, to stress-strain characteristics under reversed stress, and to other physical properties. Other methods discussed involve assumptions regarding the shape of the S-N curve. Tests utilizing special loading conditions are also discussed.

Declassified AEC Reports The following reports have been selected from a bibliography of declassified and unclassified reports on research and development work sponsored by the Atomic Energy Commission. Copies of the reports can be obtained by writing to the addresses of the issuing installations given at the head of each group of reports.

Alabama University
University, Ala.

Coatings for the Protection of Low Carbon Steel at Elevated Temperatures. *J. H. Handwerk and T. N. McVay, 1952, 33 pp.* Coatings for the protection of sheet iron from oxidation at elevated temperatures were compounded. These coatings were made by adding a refractory material to the mill batch of a ground-coat enamel. Chromium oxide and aluminum hydroxide were used. It was found that coatings containing chromium oxide did not withstand high temperatures as well as coatings containing aluminum hydroxide. Coatings containing aluminum hydroxide were tested and found to be satisfactory for protecting sheet iron at temperatures up to 1400 F for a period of 100 hr. These coatings were also found to withstand a flame impingement test in which a temperature of 1620 to 1650 F was maintained for two hours.

Iowa State College
P.O. Box 14A, Station A
Ames, Iowa
Attn: Dr. F. H. Spedding

Thermal Conductivity of Metals at High Temperatures. *Paul H. Sidles and G. C. Danielson, Dec. 1951.* A new method of measuring thermal diffusivity and hence thermal conductivity of metals is suggested. Like previously reported dynamic methods, this method uses a heat source, whose temperature varies sinusoidally, located at one end of an effectively infinite rod. Unlike these methods only one period of the heat wave is required to eliminate the unknown coefficient determining the heat lost by radiation since both velocity and amplitude decrement of the heat wave are measured. The new method is faster in taking data and simpler in computation. The thermoelectric potentials from two thermojunctions are amplified and plotted on a Brown "Electronic" recorder in order to obtain a permanent record of all necessary data for computing the thermal diffusivity. Results for copper over the temperature range 0 to 560 C and for thorium over the temperature range 0 to 430 C are given.

(Continued on page 190)

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PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO

Ready to give you on-the-job service . . .

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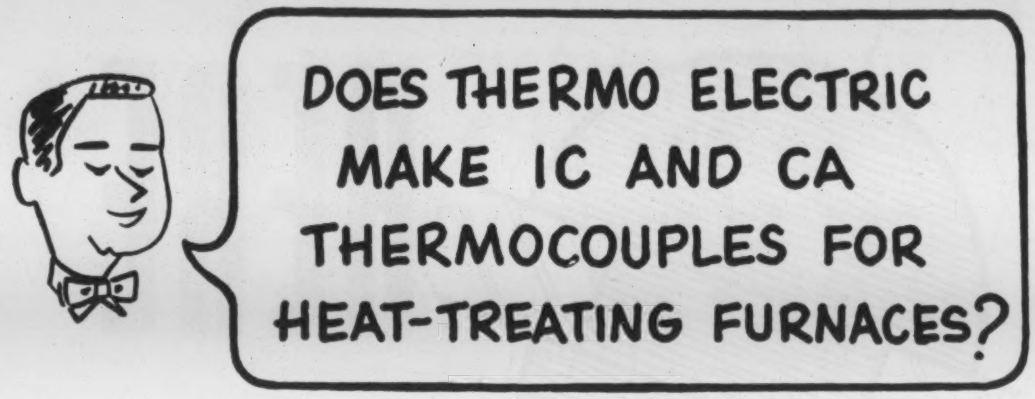
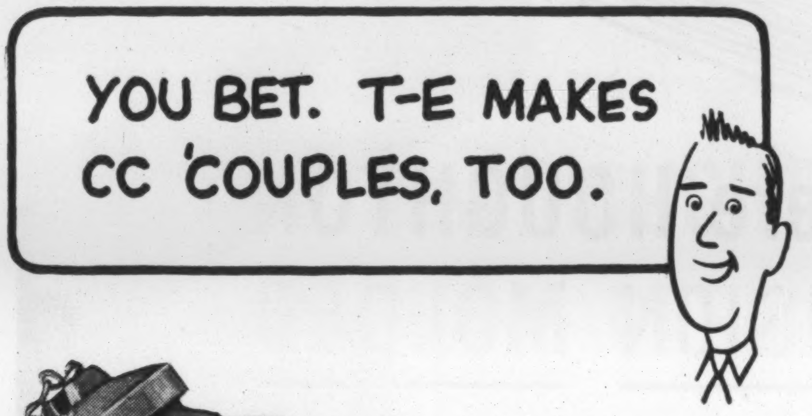
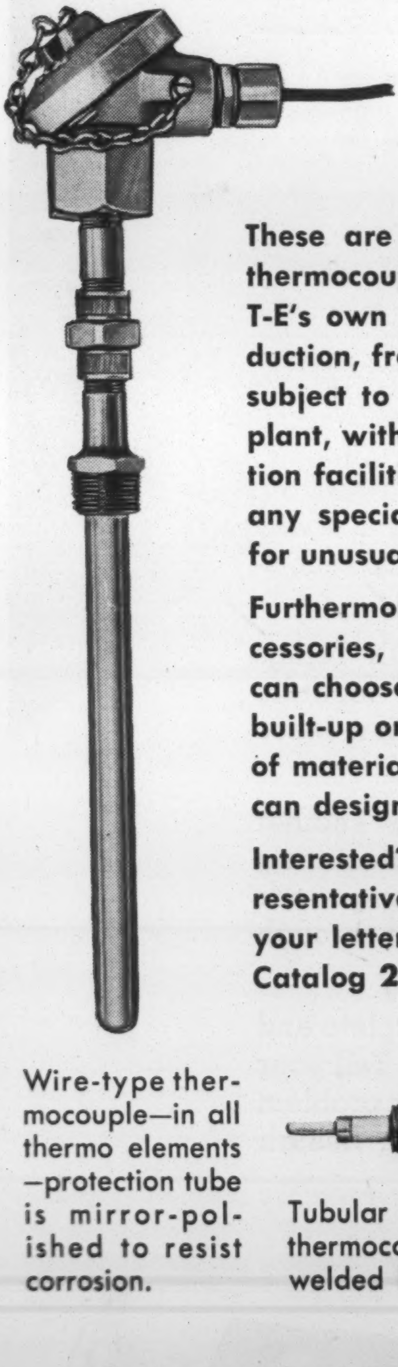

DOES THERMO ELECTRIC MAKE IC AND CA THERMOCOUPLES FOR HEAT-TREATING FURNACES?


YOU BET. T-E MAKES CC 'COUPLES, TOO.

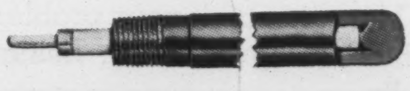
These are three of T-E's many, standard thermocouples. They are manufactured in T-E's own plant, where every step in production, from calibrating to final testing, is subject to rigid quality control. This same plant, with its excellent design and production facilities, is at your service to develop any special thermocouples you may need for unusual applications.

Furthermore, T-E makes thermocouple accessories, including protection tubes. You can choose tubes from a large selection of built-up or bar stock types in a wide range of materials. If you need special tubes, T-E can design them, and produce them.

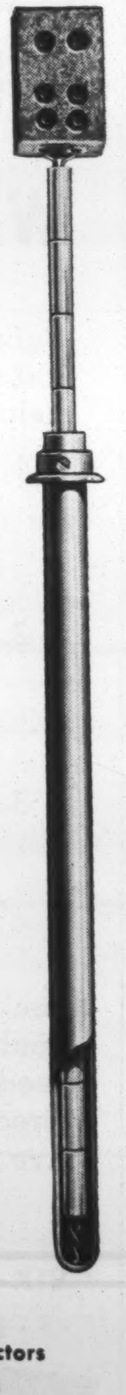
Interested? Want the name of the T-E representative nearest you? Let us know, on your letterhead. Want more data? Ask for Catalog 22-G.



Wire-type thermocouple—in all thermo elements—protection tube is mirror-polished to resist corrosion.



Tubular type, Iron Constantan thermocouple—cut-away shows welded hot junction.



Wire type, Chromel Alumel thermocouple — protection tube has open cold end to maintain oxidizing atmosphere.

Pyrometers • Thermocouples • Protection Tubes • Quick-Coupling Connectors
Thermocouple and Extension Wires • Resistance Bulbs • Connector Panels

Thermo Electric Co., Inc.
SADDLE RIVER TOWNSHIP, ROCHELLE PARK POST OFFICE, NEW JERSEY
IN CANADA—THERMO ELECTRIC (Canada) Ltd., BRAMPTON, ONTARIO

For more information, turn to Reader Service Card, Circle No. 362

Contents Noted

Reports

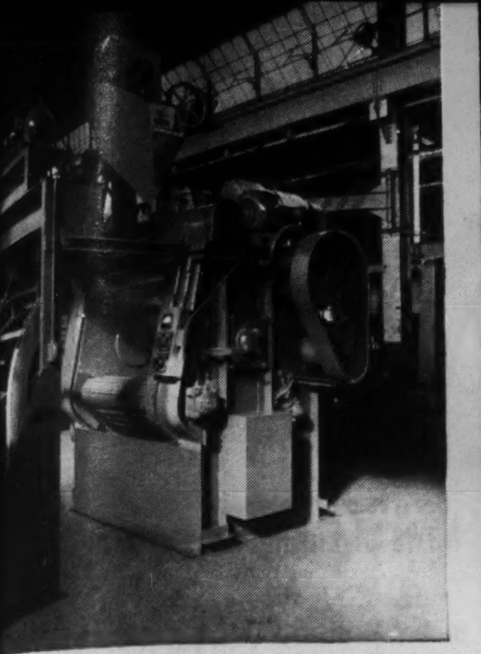
Electrical Properties of Thin Metallic Films. *D. B. Barker and W. C. Caldwell, Mar. 20, 1952. 14 pp.* The Hall coefficient and conductivity of silver films were measured by a d.c. method and comparisons with the theoretical calculations of Fuchs and Sondheimer were made. Films from 150 A to 1500 A in thickness were deposited by evaporation at pressures below 10^{-2} microns. The electrical properties were studied at liquid nitrogen, dry ice and acetone, and room temperatures. Film-thickness measurements were made by the interferometer method. Electron diffraction and electron micrograph pictures were taken to study aggregation and to check on the purity of the films. The electron micrographs show aggregation in films less than 300 A thick. The electrical measurements also indicate this change in the thinnest films. A variation of Hall coefficient and conductivity agreement between theory and experiment was indicated.

Arcos Corporation
1500 S. 50th St.
Philadelphia 43, Pa.

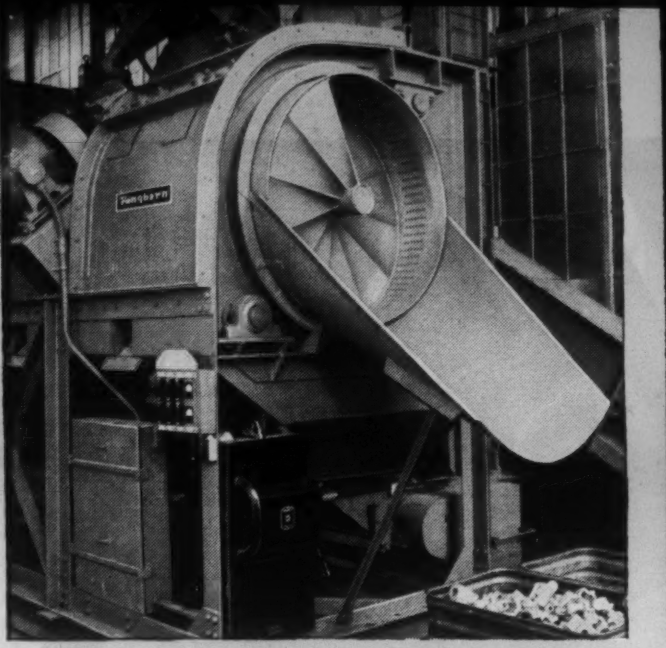
The Incidence of Cracking in the Welding of Type 347 Steels. *Lorin K. Poole, May 22, 1952.* The major fabricators of stainless steels were visited to determine the nature and extent of cracking difficulties encountered in the welding of Type 347 steel. Out of the twenty-three fabricators all reported having seen crater cracks, 78% hot short cracks or microfissuring, 39% base metal cracks, 22% cracks after stress relief, and 13% have observed "star" cracks. Fully austenitic welds are most susceptible to cracks. Electrodes having a lime type coating and whose compositions are balanced to give at least 5% ferrite in non-dilution weld pads are least susceptible to microfissures and "Star" and crater cracks. Differences of opinion exist as to the causes of base metal cracks and the various types of cracks observed after stress-relief.

●

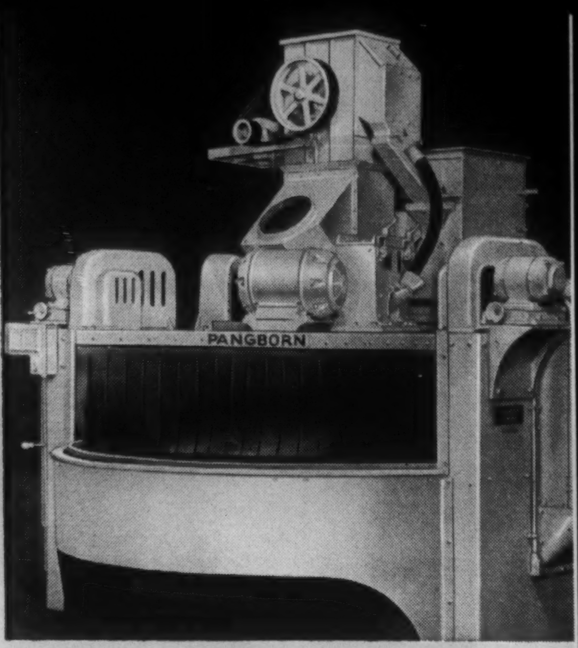
We Have Moved
Our new address is:
430 Park Avenue
New York 22, N. Y.



ngborn Blastmaster® Barrels for top efficiency batch cleaning. Newest addition to Pangborn e, features abrasive-tight door and automatic ow-out torque arm.



Pangborn Continuous-Flo ROTOBLAST Barrels for cleaning steady flow of miscellaneous work quickly. Operated by one man on production line basis.



Pangborn ROTOBLAST® Tables for semi-continuous blast cleaning. Types and sizes for castings of all sizes, surfaces, intricate shapes, and pockets.

Pangborn's 50 years of progress

offer you a complete line of equipment for every blast cleaning and dust control need

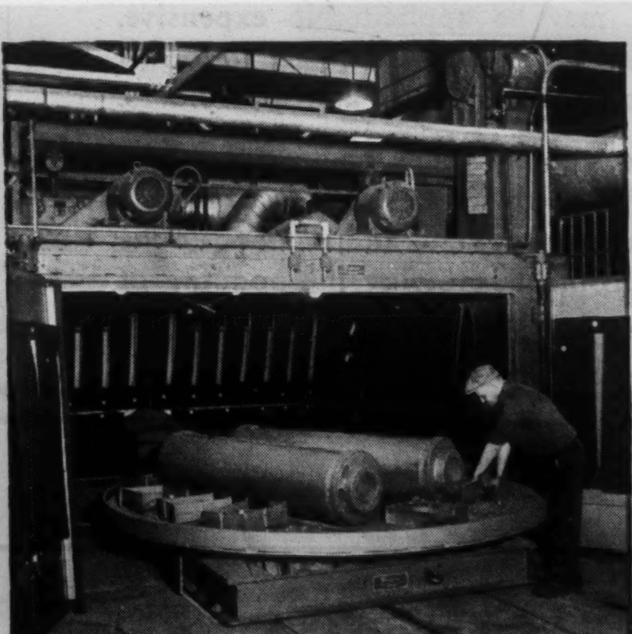
Fifty years of know-how... a half-century of research and development... and today Pangborn Blast Cleaning and Dust Control Equipment promises *and delivers* better, faster, cheaper performance on any foundry job. Shown here are just a few machines from Pangborn's *complete line* of equipment.

Pangborn engineers and equipment can save *you* time, labor, and money. Our engineers will be happy to work closely with you, in recommending the exact Pangborn unit you need, and in developing new equipment when necessary. No matter what you clean—large or small castings, ferrous or non-ferrous work... or whatever dust problem you have, it will pay you to find out how Pangborn can help you.

Send for the Pangborn bulletins that fit your needs. Write: PANGBORN CORPORATION, 1700 Pangborn Blvd., Hagerstown, Md.

FIFTIETH ANNIVERSARY
1904-1954

angborn ROTOBLAST Table-Rooms clean castings rom a few pounds to 2½ tons. Extremely efficient or jobbing foundries. Perfect for all-purpose last cleaning.

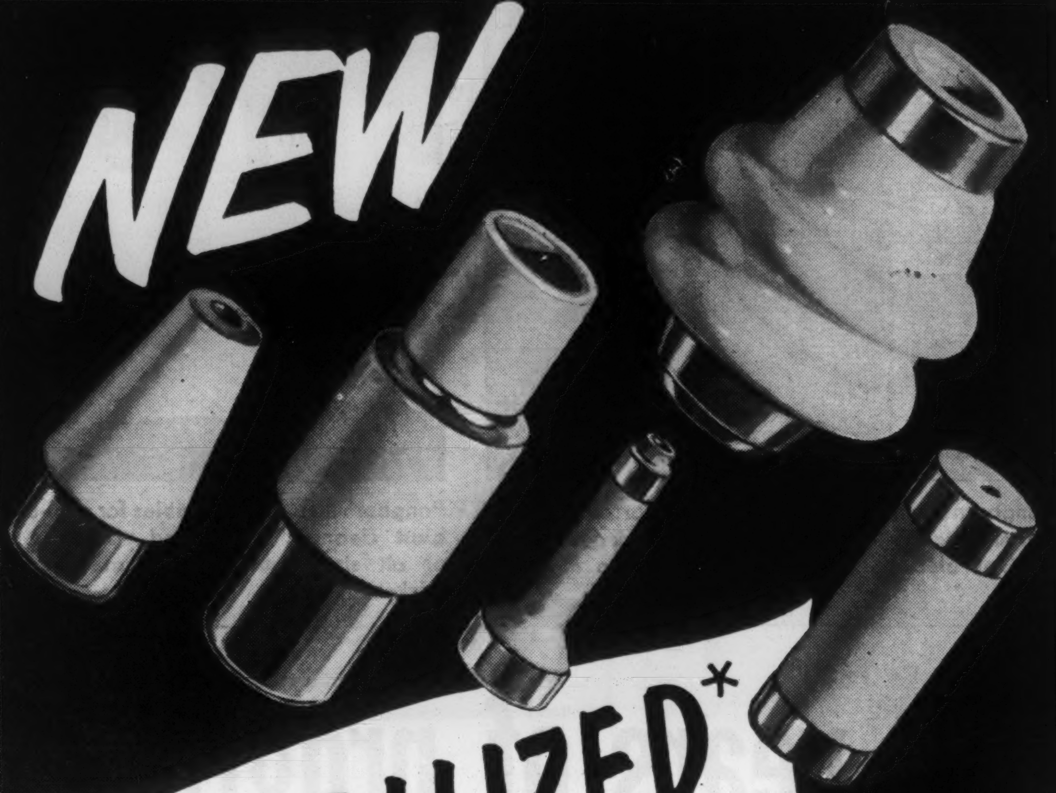


Pangborn Airless ROTOBLAST Rooms for general blast cleaning of extra-large and miscellaneous castings. Operated from outside.

Pangborn Dust Control Equipment to reduce housekeeping costs, minimize dust damage to machinery, improve employee morale and community relations. For any size requirement.

For more information, turn to Reader Service Card, Circle No. 453

NEW



METALLIZED* CERAMICS

FOR USE WITH BOTH HARD AND SOFT SOLDERS

Frenchtown's new *single metallic coating* on refractory ceramic bodies provides a surface to which solders with melting points from 275° F. to 1600° F. may be applied. No expensive, intermediate nickel and/or copper plating is needed to form a strong, firmly adhering bond with both hard and soft solders.

Now is the time to reexamine your requirements and specifications. Look to Frenchtown's new METALLIZED CERAMICS to save you production time and money. Phone or write for help on any problem involving the bonding of ceramics to metal parts or ceramics to ceramics.

*Patent Applied For

Frenchtown
PORCELAIN COMPANY
84 MUIRHEAD AVE. . . . TRENTON 9, N.J.

For more information, turn to Reader Service Card, Circle No. 372

news of ENGINEERS COMPANIES SOCIETIES

News of Engineers

H. E. Kaye, assistant chief engineer, Rollway Bearing Co., Inc., has been named chairman for the next year of the Roller Bearing Engineering Committee, Anti-Friction Bearing Manufacturers Association.

Robert O. Isenbarger has been named chief engineer in charge of all company field engineering, Chicago Rawhide Manufacturing Co. **Alfred S. Berens** was appointed director of engineering for the company.

Thurston Klayton, director of engineering research and development, Luria Engineering Co., has been given the additional title and duties as chief engineer.

James L. Murray, formerly chief of the Engineering Division for the Air Force in Europe, has joined The Garrett Corp. as engineering representative.

George D. Creelman has been named technical service director, Bjorksten Research Laboratories, Inc.

E. Finley Carter, vice president and technical director, Sylvania Electric Products, Inc., has accepted the position of manager of research operations, Stanford Research Institute.

Norman B. Pilling, director of the Bayonne Research Laboratory, The International Nickel Co., Inc., will assume new duties as assistant to the vice president-manager of the company's Development and Research Div.

Dr. W. Andrew Wesley, assistant director since 1939, succeeds Mr. Pilling as head of the laboratory, with the title of manager.

David B. Acker has been appointed manager of industrial engineering for Convair's San Diego division.

John F. Green has been named assistant general manager of the Ditzler Color Div., Pittsburgh Plate Glass Co. **Walter W. Ethier, Jr.,** succeeds Mr. Green as factory manager of the Atlanta Paint Div., and **Charles R. Holman,** manager of the Selectron Dept., replaces Mr. Ethier as assistant divisional mana-

REYNOCELL*

THE MIRACULOUS NEW MATERIAL WITH BOUNDLESS USES

In CONSTRUCTION

because of its light weight, insulation and fire, moisture, fungi and pest resistance . . . movable partitions • folding partitions • interior curtain walls • residential doors • industrial and garage doors • solar shades • advertising signs • lean-to bomb shelters • shelving, etc.

For PORTABLE EQUIPMENT

because of its light weight and structural strength . . . billboards • pallets • platforms • stage scenery • trailer and truck body parts • work stands, etc.

For INSULATED STRUCTURES

because of its excellent thermal insulation, light weight and strength . . . liners for refrigerator trucks and cars • walk-in refrigerators • refrigerated vending machines • shipping containers • oven jackets • heat baffles • preheating chambers • chicken incubators • bakery proof boxes, etc.

For FURNITURE

because of its modern beauty, light weight and fire and moisture resistance . . . desks and tables • cabinets • drafting boards • bed ends • store fixtures • portable bars, etc.

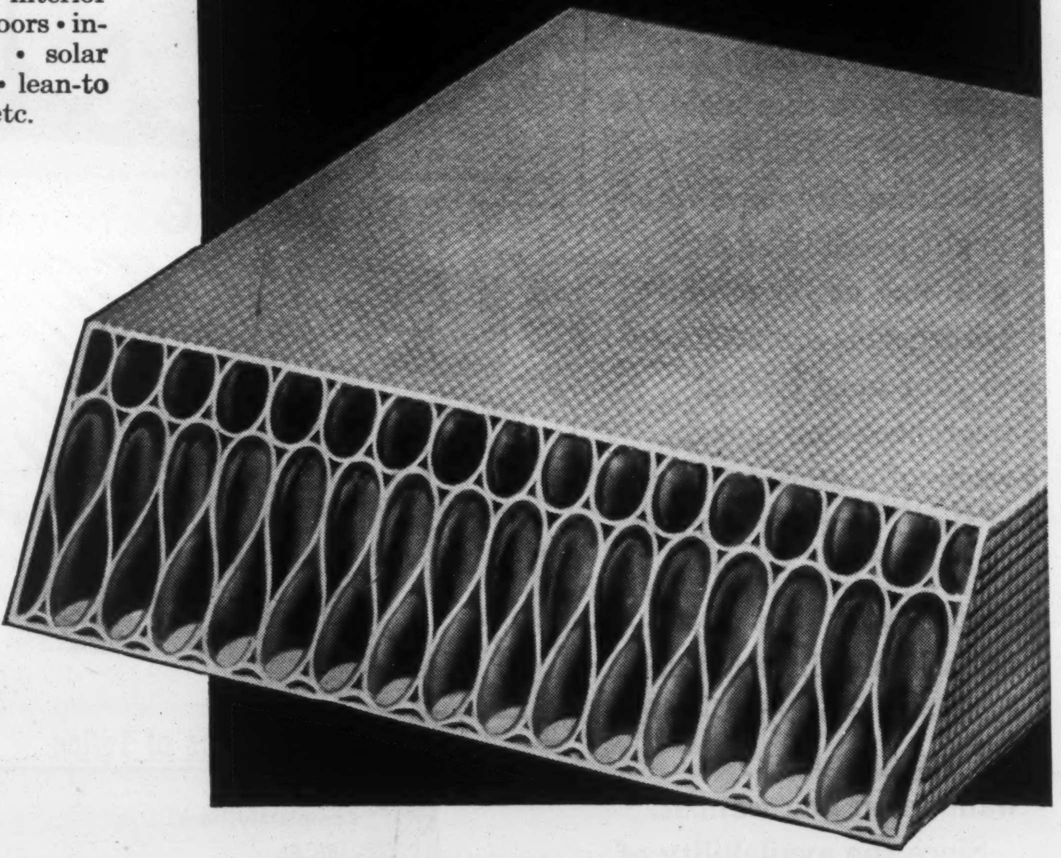
WHAT REYNOCELL IS:

Reynocell panels are extremely light, strong, rigid, prefabricated structural units. They have a honeycomb core of resin-impregnated kraft paper to which aluminum facings are securely bonded.

ITS PROPERTIES:

(Typical, based on 4″ thick panels. Comparably favorable properties apply to other thicknesses.)

Weight—1.46 lb/sq. ft.
Bending Strength—180 lb/sq. ft. of uniformly distributed load on 8′ span
Deflection—¼″ with 47 lb/sq. ft. of uniformly distributed load on 8′ span
Crushing Strength—70 psi
Thermal Insulation (U factor)—.135



REYNOLDS Engineering Service

Reynolds engineers are working with a number of manufacturers on a variety of applications. Their assistance is also available to help you apply the many advantages of Reynocell Panels to your products.

Call your nearby Reynolds office listed under "Aluminum" in classified phone directories. Or write for more complete information and answers to your design questions. New applications and test data that may be helpful to you are accumulating every day. Reynolds Metals Company, 2560 So. Third Street, Louisville 1, Kentucky.

*T.M. registered

REYNOLDS ALUMINUM

MODERN DESIGN HAS ALUMINUM IN MIND

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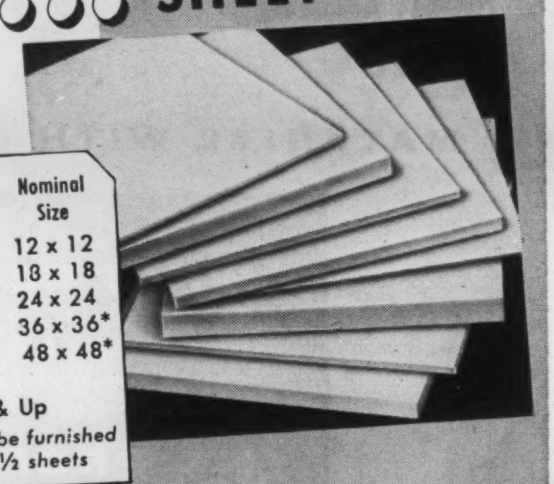
Teflon*... SHEET

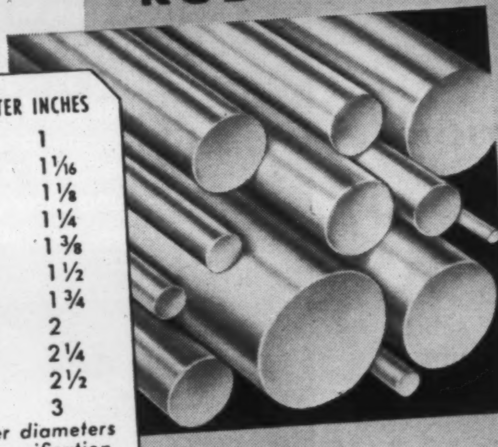
Your Best Source Is JOHN CRANE



Thickness Inches	Nominal Size
1/16	12 x 12
3/32	18 x 18
1/8	24 x 24
3/16	36 x 36*
1/4	48 x 48*
3/8	
1/2 & Up	

* Can be furnished in 1/2 sheets

ROD



DIAMETER INCHES	
1/4	1
5/16	1 1/16
3/8	1 1/8
7/16	1 1/4
1/2	1 3/8
9/16	1 1/2
5/8	1 3/4
3/4	2
7/8	2 1/4
	2 1/2
	3

Other diameters on specification

TUBING

TYPICAL SIZES INCHES

O. D.	I. D.
3/8	1/4
1/2	3/8
3/4	1/2
1	3/4
1 1/2	1
2 1/2	1 1/2
3	1 3/4

HERE'S WHY: You can order in quantity and in a wide variety of sizes—and be certain of complete uniformity throughout. Our strict density control assures you thoroughly non-porous Teflon—free from any flaws which might possibly affect your end use or product. Dimensions are accurate to your most critical tolerances—no rejects, waste of material or loss of time. You get product purity—Teflon at its best in every one of its remarkable characteristics. Delivery is prompt—you get the quantity you want when you want it.

Since the availability of Teflon, "John Crane" engineers have worked with Industry to successfully solve innumerable problems and develop new applications. *You can benefit from their experience and know-how.*

Characteristics of Teflon

CHEMICAL
Completely inert.

ELECTRICAL
Very high dielectric strength.
Extremely low power factor.

THERMAL
Temperature range −300° to +500° F.

MECHANICAL
Strong, flexible, weather resistant.

LOW COEFFICIENT OF FRICTION
Absolutely non-stick.

* DuPont Trademark

Request full information and ask for our bulletin, "The Best in Teflon." Crane Packing Co., 1827 Belle Plaine Ave., Chicago 13, Ill. • In Canada: Crane Packing Co., Ltd., 617 Parkdale Avenue, N., Hamilton, Ont.

"JOHN CRANE"
CHEMLON

JOHN CRANE
CRANE PACKING COMPANY

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news of | ENGINEERS

ger of the Newark, N. J. paint division.

John Upton, Jr. has been named general manager of The Hallden Machine Co.

Archie F. Wilson has been appointed director of manufacturing, Hydraulic Press Manufacturing Co.

Dr. R. P. Dinsmore, vice president in charge of research and development, Goodyear Tire & Rubber Co., was recently honored at a testimonial dinner celebrating his 40 years of service with the company. Dr. Dinsmore received a diamond studded pin, emblematic of his long term of service.

Robert W. Clarke has been named manager of the new Pennsylvania Salt Manufacturing Co.'s plant at Delaware, Ohio. **Vance N. Wilson** has been named as manager of the company's plant at Chicago Heights, Ill.

L. J. Rohl has been appointed to the newly created position of chief metallurgical engineer of United States Steel Corp. In this new position, Mr. Rohl will coordinate the metallurgical activities of all divisions of U. S. Steel. **R. W. Simon** was named to succeed Mr. Rohl as chief metallurgical engineer, operations-steel.

Dorothy M. J. Tracey was elected president of Tomkins-Johnson Co.

Paul A. Pierce has been appointed manager of operations for the Continental Foundry & Machine Co.

John W. Dixon, executive vice president of Clevite Corp., is being named to coordinate the activities of the company's new Research Center with those of the other units in the corporation. In the newly created post of vice president in charge of coordination of research and new product development, Mr. Dixon will devote his full time to the activities of the Center.

George Saum has been named manager, Taylor Forge Aircraft Products Div., Taylor Forge & Pipe Works.

Frazier O. Stratton has been named chief engineer, Sterling Engineering Co., a subsidiary of American Machine & Foundry Co.

Marcel F. Bachner, formerly vice president and treasurer, has been elected president and treasurer of

Yours for the asking...

up-to-the-minute technical data on **CAST STAINLESS STEEL CASTINGS • FITTINGS • VALVES**

1. STANDARD PRACTICE SP-42 . . . Eight page folder listing detailed specification for 150# corrosion resistant cast flanged valves, flanges and flanged fittings.

2. DESIGN FACTORS OF STAINLESS STEEL VALVES . . . Four page technical folder explaining basic design factors which a good stainless steel gate or globe valve should incorporate.

3. FLOW DIAGRAMS . . . Four page folder describing basic stainless steel valve designs in terms of fluid flow. Uses and limitations of each major type are discussed.

4. MATERIALS SELECTION CHART . . . Four page chart designed to assist in the selection of the most economical alloy for a given corrosive problem. More than 350 specific corrosives are included.

5. ALLOY REFERENCE CHART . . . Four page pamphlet listing alloy designations, applications, properties and analysis of corrosion and heat resisting alloys.

6. HOW TO GET THE RIGHT VALVE . . . Eight page folder giving information needed to enable manufacturer, supply company or sales representative to fit the proper valve for the application. Tells user or buyer how to get what he needs when ordering a valve.

7. CAST STAINLESS STEEL IN THE PAPER INDUSTRY . . . Eight page folder describing how stainless steel castings, valves and fittings are used to beat corrosion in the paper industry

8. THREADING STAINLESS STEEL . . . Four page folder describing specific high production machining operations on stainless steel valve parts. Speeds, cutting angles, coolants and tooling are discussed.

9. HIGH TEMPERATURE CHARACTERISTICS . . . Technical data chart giving high temperature characteristics of heat resistant alloys.

10. PROPERTIES OF CAST STAINLESS ALLOYS . . . Technical data chart giving designations, composition, mechanical and physical properties of cast stainless alloys.

11. MOLYBDENUM BEARING STAINLESS CASTINGS . . . Four page folder discussing the properties and applications of molybdenum bearing cast stainless alloys.

12. USES FOR CAST MONEL . . . Eight page booklet describing properties and applications of cast monel.

13. WHAT TYPE HIGH ALLOY CASTINGS . . . Four page folder describing selection of alloy types in keeping with government regulations.

14. QUIKUPL STAINLESS STEEL FITTING . . . Technical manual describing design, applications and limitations of revolutionary new type stainless fittings.

15. QUIKUPL—IMPARTIAL ANALYSIS . . . Four page folder objectively evaluating Quikupl fittings. Prepared by an independent engineering consultant.

16. SHELL MOLDED STAINLESS CASTINGS . . . Eight page technical discussion explaining the development of a method for casting stainless steel in shell molds.

17. FIGURE NUMBER CROSS REFERENCE CHART . . . Four page folder showing equivalent figure numbers of the five leading stainless steel valve producers.

18. GETTING THE MOST OUT OF YOUR VALVES . . . Four page technical discussion explaining selection, installation, inspection and maintenance of stainless steel valves.

CLIP THIS COUPON

1	7	13
2	8	14
3	9	15
4	10	16
5	11	17
6	12	18

COOPER ALLOY

THE COOPER ALLOY FOUNDRY CO. • HILLSIDE, N.J.

Los Angeles, San Francisco, Oakland, Houston, Chicago, Detroit, Philadelphia, Hartford

Leading producers of STAINLESS STEEL valves, fittings and castings

Check for FREE LITERATURE

Name________________

Position________________

Company________________

Address________________

City________ Zone______ State________

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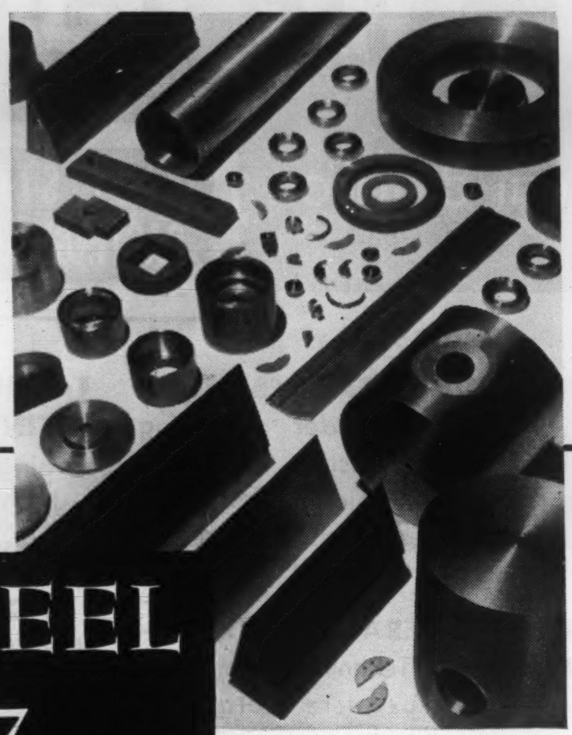
Whenever Maximum Density
In
Limited
Space Is
Needed....



FANSTEEL
77
METAL

Is Your Logical Choice

When you need a metal that is extremely *heavy*, yet stronger than cast iron, easily fabricated and machined into practically any desired shape, easily joined to other metal parts, then you need Fansteel 77 Metal.

Fansteel 77 Metal is fulfilling dozens of important uses, from inertia members in delicate instruments to counterweights for aircraft ailerons, rotors, governors, flywheels, vibration dampers.

Because:

WEIGHT — Twice as heavy as steel, 50% heavier than lead.

STRENGTH — Much greater than cast iron, superior to most non-ferrous metals and alloys, comparable to worked low-carbon steels.

WORKABILITY — Machines almost as easily as cast iron, can be brazed or silver soldered. Is often sintered to within 0.005" of final dimensions.

NON-MAGNETIC — Resistant to almost all forms of atmospheric corrosion. Good thermal and electrical conductivity.

AVAILABLE — Finished or semi-finished parts made to your specifications by powder metallurgy in the Fansteel plant—no rejects, no scrap losses. Also available in bars, rods, rings, disks, special shapes.

Ask for your copy of the bulletin *Fansteel 77 Metal.*

FANSTEEL
WORLD'S LARGEST PRODUCER OF REFRACTORY METALS

Fansteel Metallurgical Corporation
K541
NORTH CHICAGO, ILLINOIS, U.S.A.

For more information, turn to Reader Service Card, Circle No. 320

news of ENGINEERS

Chicago Molded Products Corp. **Edward F. Bachner, Sr.** has been named to the newly created post of chairman of the board. **John J. Bachner** has been named as executive vice president and general manager.

Peter J. Jensen has been named manager of manufacturing at Carboloy Dept., General Electric Co.

E. T. Walton, formerly chief metallurgist at Crucible Steel Co.'s Midland, Pa., Works, has been appointed to the company's central metallurgical offices in Pittsburgh in the capacity of chief engineer. At the same time it was announced that **Charles W. Schott** was appointed plant metallurgist at Midland.

Peter E. Kyle has resigned his position as professor of Metallurgical Engineering at Cornell University to join the research and development firm of Lessells and Associates, Inc., as vice president.

C. Howard George has been named executive vice president, and **L. S. Holstein** has been named vice president, the New Jersey Zinc Co.

Dr. Clyde A. Crowley has been appointed to the position of director of development engineering and research, the Given Manufacturing Co.

Howard H. Casey has been named director of engineering, The Midvale Co.

P. L. Coddington has been appointed manager of the Alloy Tube Div., Carpenter Steel Co. Mr. Coddington has been assistant to the president at the firm's Alloy Tube Div. since August 1953.

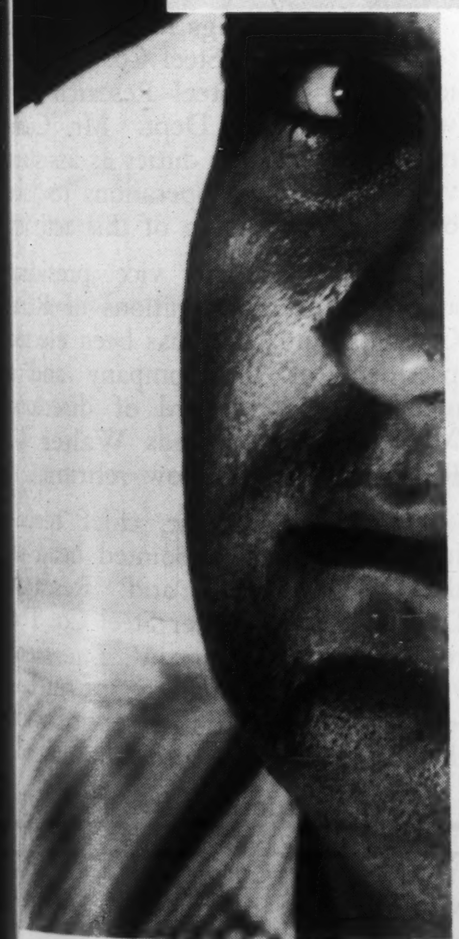
J. W. Marrinan was elected vice president in charge of operations, Superior Steel Corp.

Frank S. King has been named technical manager for tires, Dunlop Tire and Rubber Corp. Mr. King will supervise product development, technical service and quality control of tire and tube manufacture.

Arthur C. Bryan has been appointed vice president and general manager of consumer products, and **William H. Feathers,** vice president and general manager of industrial products, National Carbon Co., a Division of Union Carbide and Carbon Corp. At the same time it was announced that **Walter A. Steiner** has been appointed vice president in charge of development.

(Continued on page 198)

NOW look how they're using G-E POLYESTER RESINS to make ELECTRODE HOLDERS



That wonderfully versatile, new combination of materials—General Electric polyester resins reinforced with glass fiber—is now lending its great potential to the electrical equipment industry!

Erico Products, Inc., Cleveland, Ohio, uses G-E polyester-glass plastics to mold their five-part CADDY Arc Welding Electrode Holder. The following report is from Erico:

"Handle grip better and cooler than fiber tubing formerly used: not subject to moisture absorption, lamination breakdown or warping . . . insulating jaws able to withstand extreme operating heat and high impact . . . excellent electrical properties. Increased design flexibility lowered our costs—assured customers of increased operational life and service."

How can you profit from G-E polyesters?

Check the products you make to see where G-E polyester resins can benefit *you*. G-E service and technical know-how are ready to aid you in design and production problems. Ask your custom molder about G-E polyester-glass plastics; he knows G.E. as a dependable supplier of the resins that make this new material possible.

For further information, write us on company letterhead for G-E polyester resin technical bulletin CDC-238. *General Electric Company, Section 419-4A, Chemical Materials Dept., Pittsfield, Massachusetts.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information, turn to Reader Service Card, Circle No. 486

...How about
Malleable?

Make Your Products Tough–
Durable–Safe

The ability of malleable iron to withstand severe impact and shock and its high resistance to atmospheric corrosion make malleable castings extremely valuable for products that must be rugged and durable.

Machining time and cost are often saved because malleable can be cast close to final form and even formed to final dimensions by fast and inexpensive press or coining operations. No ferrous material can be machined with greater ease.

Take advantage of malleable's toughness, ductility and resistance to shock and corrosion when designing new products or when looking for ways to cut costs or improve present production. Call a malleable foundry and have their engineers go over your products with you. They will show you how to utilize malleable's properties to design better products at lower cost.

RIDGID
HEAVY DUTY
14

Famous
RIDGID
Pipe Wrenches
Use Malleable

The Ridge Tool Company makes the handle and housing of their pipe wrenches of tough, rugged malleable to assure dependable and safe performance. Every RIDGID Pipe Wrench carries an unconditional guarantee that the housing will not break or distort or it will be replaced free.

Send for "Malleable Iron Facts" Bulletin No. 46.
Data on design, application and physical properties of malleable iron to help you design with malleable.
Just write to The Malleable Founders' Society.

Malleable
FOUNDERS' SOCIETY

1800 Union Commerce Building
Cleveland 14, Ohio

For more information, turn to Reader Service Card, Circle No. 368

news of | ENGINEERS

W. E. Montgomery has bee appointed chief engineer and **John Gabrenas** has been named assistan chief engineer, Carbide Div., Firth Sterling, Inc.

William Irrgang was recentl elected president and general manager of The Lincoln Electric Co **James F. Lincoln,** elected chairman of the board, will remain active i the direction of company policies

George F. Fischer has bee named director of the Metallurgica Department, Sam Tour & Co., Inc

William T. Cherry has bee appointed to the position of manager of application engineering, Th Formsprag Co.

K. J. Bossart has been appointed assistant chief engineer, Convair's San Diego Div. Mr. Bossart will b in charge of engineering for one o Convair's guided missile projects

Dr. Augustus B. Kinzel ha been appointed director of research Union Carbide and Carbon Corp In his new capacity, Dr. Kinzel wil be responsible for the administration and coordination of the research activities of all company divisions.

M. E. Cummings has been name to head Crucible Steel Co. of America's new Tool Steel Research Div within the Sales Dept. Mr. Cummings resigned his duties as assistan vice president of operations to tak over the directorship of this activity

C. I. Bradford, vice presiden and director of operations of Rem Cru Titanium, Inc., has been electe president of the company and member of the board of directors Mr. Bradford succeeds **Walter U Reisinger** who is now retiring.

Dr. Carl B. Post, chief metallurgist, has been appointed head o the Metallurgical and Research Depts., The Carpenter Steel Co. Th retirement of **George V. Luerssen,** vice president in charge of metallurgy, after 47 years of service wit the company was also announced

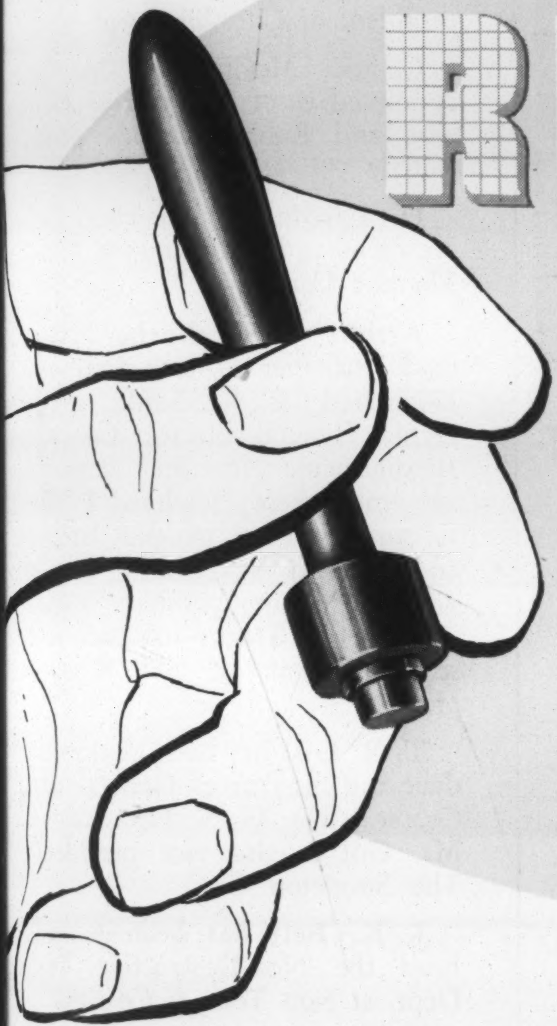
F. A. Gruetjen has been appointed to the staff of the president A. O. Smith Corp. Mr. Gruetjen, with the title of director of aeronautical development, will advise the company in all technical matters connected with the production o aeronautical components.

Eugene A. Luxenberger has been elected vice president of United States Rubber Co. and appointed

C. L. FROST & SON says . . .

Super LA-LED®

FASTER MACHINING
LEADED STEEL BARS



REPLACES BRASS

SUCCESSFULLY

saves 3¢ per part

This screen door handle, a part of Frost's steel hardware line, was formerly made of brass only because no steel was found with machinability to produce the part successfully.

Now, with the exceptional machinability of Super LA-LED, this part is machined at the same speed as brass . . . but at a savings of 3¢ per part. This is another example of the real production savings obtainable by using Super LA-LED instead of brass. It is worth a review of parts in *your* shop.

In addition to lowering part costs, Super LA-LED possesses good carburizing qualities, sound cross section and good ductility. Super LA-LED is available today, cold finished, in rounds $\frac{5}{16}$" through 3", and in hexagons $\frac{5}{16}$" through 1½". Order a trial lot and see how it can help you trim your costs.

Send for New Folder on Super LA-LED

Super LA-LED
REPLACES BRASS

La Salle STEEL CO.

Manufacturers of the Most Complete Line of Cold-Finished Carbon and Alloy Steel Bars in America

LA SALLE STEEL COMPANY
1418 150th Street
Hammond, Indiana
Please send me your new Bulletin on Super LA-LED

Name____________________
Title____________________
Company____________________
Address____________________
City__________ Zone____ State________

For more information, turn to Reader Service Card, Circle No. 469

Big SAVINGS ON Small PARTS

Eliminate Costly Machining with MICROCAST

This industrial component was formerly produced from solid stock by conventional machining methods. When produced by the MICROCAST process of precision investment casting, substantial savings resulted . . . close to 50% of each production dollar.

The MICROCAST technique enables you to economize on small parts and components by eliminating or substantially reducing costly machining operations. Another important advantage is its ability to cast high-temperature alloy parts and components at a lower cost than any other production method.

Write for free booklet. Full color sound film on the Microcast process available without charge.

MICROCAST® PRECISION CASTINGS PROCESS

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MICROCAST DIVISION, Austenal Laboratories, Inc.
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7001 South Chicago Avenue, Chicago 37, Ill.

THE ORIGINAL PROCESS FOR MASS PRODUCING PRECISION INVESTMENT CASTINGS

For more information, turn to Reader Service Card, Circle No. 308

general manager of its footwear and general products div. **Gregg T** **Ward** succeeds Mr. Luxenberger as assistant general manager of th division.

T. E. Waterfall has been elected president of the Chrysler Motor Parts Div., Chrysler Corp. In his new position, he succeeds **Charles L. Jacobson** who was elected vice president of Chrysler Corp.

C. S. McChesney has been appointed chief engineer of Dunlop Tire and Rubber Corp.'s plant in Buffalo.

H. E. Martin has been elected president and a director of Metal & Thermit Corp.

Arthur J. Sherburne has been made manager of technical service Laminated & Insulating Products Dept., General Electric Co. Other appointments in the department announced were: **Richard T. Walsh** as supervisor of molded laminates, and **Ronald W. Staley** as superviser—insulating products engineering. **Carl A. Drake** has been named superintendent of the Coshocton plant.

T. R. Gill has been elected president and director of General Supply Co. and The G. S. Equipment Co. Mr. Gill is also vice president of The Singleton Co.

J. K. Bell has been named to head the Non-Destructive Testing Dept. at Sam Tour & Co., Inc.

H. N. Nuntzicker has been elected vice president in charge of research, United States Gypsum Co. **C. W. Desgrey,** formerly general manager of operations, has been elected vice president in charge of manufacturing.

Lee H. Morrison has been named editor of the national magazine *Plating,* succeeding **Alexander L** **Korbelak.**

Geoffrey M. Rollason, general manager of Aluminum Co. of America's Die Casting Div., has retired after 35 years with the company. Mr. Rollason is curently serving as president of the American Die Casting Institute.

Frank L. LaQue has been elected vice president of the International Nickel Co., Inc. and manager of its Development and Research Div. A distinguished authority on corrosion, Mr. LaQue succeeds in both

FUEL

PROOF

FORCE-FEEDS 10,000 HUNGRY HORSES

Making jet engines thrive on strange diets in many climates requires the most exacting specifications in a pliable part. That's why C/R Sirvene (synthetic rubber) was the logical choice for this fuel control regulator diaphragm. It handles fuels ranging from kerosene up through the aromatics. It feeds them fast, under high pressure, and does the job dependably at –65° and 200°F. plus. Like all Sirvene parts, this diaphragm is completely custom developed—through design, compounding of oil-resistant elastomers, molding, and laboratory-like control of production. Also, it is the result of cooperation ... the complete cooperation that C/R engineers will be glad to provide for your similar problems.

FOR YOU: We will be pleased to send you our book "Engineering with Sirvene," on request.

C/R

SIRVENE

SCIENTIFICALLY COMPOUNDED ELASTOMERS

See Sweet's Product Design File $\frac{\text{le}}{\text{Ch}}$

CHICAGO RAWHIDE MANUFACTURING COMPANY

1301 Elston Avenue SIRVENE DIVISION Chicago 22, Illinois

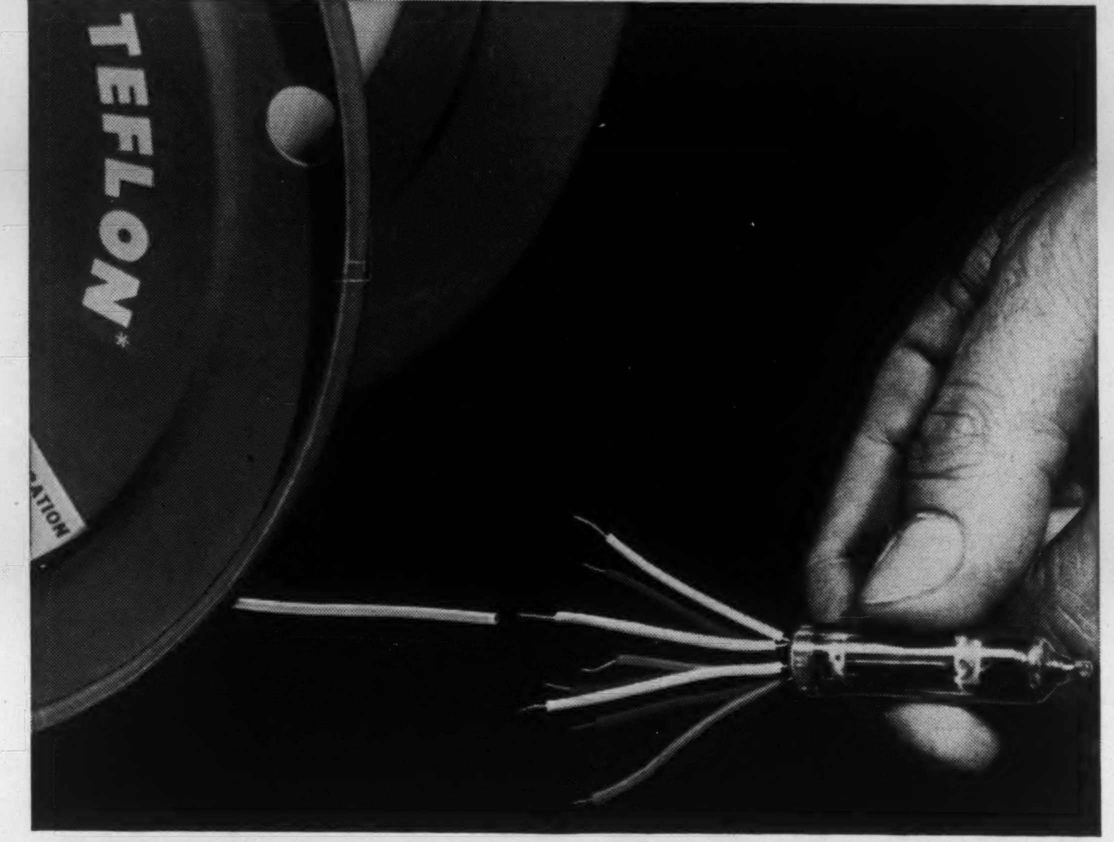
Representatives in these Principal Cities: Boston • New York • Syracuse • Buffalo • Philadelphia • Pittsburgh • Cincinnati • Cleveland Detroit • Peoria • Minneapolis • Wichita • Tulsa • Houston • Los Angeles • San Francisco • Seattle

Other **C/R** *products*

Oil Seals: Shaft and end face seals for all types of lubricant retention and dirt exclusion • Conpor: Controlled porosity mechanical leather packings and other sealing products • Sirvis: Mechanical leather boots, gaskets, packings and related products.

For more information, turn to Reader Service Card, Circle No. 492

POLYPENCO® TEFLON* SHAPES

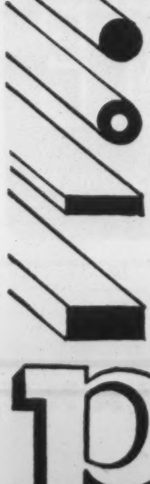


NEW! POLYPENCO® Teflon Spaghetti Tubing

- **The ultimate in insulation for wire conductors, leads, tube plugs, etc.**
- **Unaffected by heat from soldering operations**
- **Unaffected by repeated flexing**
- **Available in a choice of 7 different colors for color coding**

Now you can obtain the excellent dielectric properties of POLYPENCO Teflon in a spaghetti tubing that slips easily over AWG conductors . . . permits fast soldering of connections . . . and simplifies wiring and trouble-shooting in miniaturized UHF circuits. POLYPENCO Teflon Spaghetti Tubing also offers many desirable mechanical properties and resists weathering, chemicals, fungi, and high temperatures. Like other shapes of POLYPENCO Teflon, its quality is uniformly high in every shipment.

You can now get this new spaghetti tubing in natural, black, brown, red, green, blue and yellow colors. There's also a full range of internal diameters corresponding to American Wire Gauges 22 through 8. For convenient use, all POLYPENCO Teflon Spaghetti Tubing is supplied on reels in lengths of 100, 200, 500 or 1000 feet.



Write for price list and tubing samples

The POLYMER CORPORATION of Penna. • Reading, Penna.
In Canada: Polypenco, Inc., 2052 St. Catherine W., Montreal, P.Q.

POLYPENCO® TEFLON*
. . . nylon and other non-metallics

Warehouse stocks: Reading • Chicago • Los Angeles • Newton (Mass.) • Branford (Conn.)
**trademark for Du Pont tetrafluoroethylene resin*

For more information, turn to Reader Service Card, Circle No. 345

positions **Thomas H. Wickenden,** who has attained retirement, but will continue to serve the company as a consultant on special projects.

Hiram B. Young, formerly works manager of the Niagara Falls, Ashtubula and Montague plants of Hooker Electrochemical Co., has been elected vice president of the company in charge of eastern production. **Thomas E. Moffitt,** formerly western manager of the company's Tacoma plant has been elected a vice president in charge of western operations.

Carl E. Egeler, illuminating engineer in the Application Engineering Dept., General Electric's Lamp Div., has retired after 40 years with the company.

Colonel Horace A. Quinn, U.S.A. (Ret.) has been named manager of American Machine & Foundry Co.'s General Engineering Laboratories. Mr. Quinn succeeds **R. A. Kimes** who has been named director of engineering AMF Electronics Div., Boston.

Rosser L. Wilson has been appointed vice president in charge of engineering, the Brake Shoe Castings Div., American Brake Shoe Co.

William H. Shenkle, a gas products engineer with the Rockwell Manufacturing Co.'s Instrument Div., has been named chief engineer of the division.

Edgar W. Engle, manager of product and process development engineering, Carboloy Dept., General Electric Co., has been named manager of cemented carbide products engineering.

William D. Reed, former superintendent of fabrication at the Convair Div., General Dynamics Corp., has been appointed works manager of the Midwest Div., H. & B. American Machine Co.

Dr. Harry Walker has been appointed vice president of the Norma-Hoffman Bearings Corp.

Paul H. Tayor has been elected director and vice president in charge of the Research and Hydra Spring Div., Wales-Strippit Corp.

Herbert J. Reid has been named factory manager of the Fort Wayne plant, Mechanical Goods Div., United States Rubber Co.

(Continued on page 208)

ROLOCK

FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT

FORD MOTOR COMPANY

SAVES ½ HOUR IN HEAT TREATING CYCLE

Photographs above show two similar cycles through a roller hearth carbo-nitriding furnace at 1560°F., followed by oil quench . . . at the Rouge Dearborn Engine Plant. (Left) Rolock fabricated hairpin fixtures and pressure-welded separator screens carry Crankshaft Sprockets, while (right) Rolock fabricated stacking-type fixtures handle Oil Pump Shafts (long and short).

In both instances, through individual positioning, cycle times have been reduced ½ hour from bulk loading times: for the sprockets, from 3 hours to 2½ . . . and, for the shafts, from 2 hours to 1½. Optimum circulation of gases and quenching oil around parts improves quality . . . positioning shafts vertically minimizes run-out . . . loading and unloading are simplified.

Rolock fabricated, engineered-to-the-job heat treating equipment cuts costs . . . betters your competitive position . . . improves your products. Rolock engineers expect, and welcome, tough jobs . . . and are solving them for the country's leading metal-working plants. Our Catalogs B-8 and B-9 are packed with ideas you can use. Send for them today.

Offices in: ANDERSON, IND., CHICAGO, CLEVELAND, DETROIT, HOUSTON, LOS ANGELES, MINNEAPOLIS, PHILADELPHIA, PITTSBURGH, ST. LOUIS

ROLOCK INC. • 1282 KINGS HIGHWAY, FAIRFIELD, CONN.

JOB-ENGINEERED for better work
Easier Operation, Lower Cost

ORL54A

For more information, turn to Reader Service Card, Circle No. 436

Here's More Technical Aid In Selection And Design Of Your Fasteners And Parts

Townsend has expanded its Technical Sales Department to help you in your constant effort to improve your product, reduce unit costs and speed assembly. Here, a group of specialists works as a unit to devise the most economical and efficient methods of product assembly for all industry.

These men can serve you in several ways. They will visit your plant as fastening consultants to your design engineers and operating men. They will analyze a particular product and design special parts for it or suggest use of standard products in the assembly.

You may want them to study your entire production line for improved assembly techniques—they will even design a single part to solve a specific problem.

Another way to obtain the services of this department is to send drawings and samples of specific items for suggestions as to how they can be produced more economically.

Back of the Technical Sales Department is a company with nearly a century and a half of wire drawing and cold-forming experience. More than 10,000 standard and special parts and fasteners are produced regularly by Townsend.

In addition to the wide range of products and design experience at your command, Townsend has the tremendous capacity to produce 60-million pieces a day. This means you can depend upon Townsend to keep pace with your production lines since, in its several plants, there are enough machines of any type to handle a variety of long production runs simultaneously.

To learn how you may effect substantial savings in material costs, speed production and improve your product, write today for illustrated bulletin or use the coupon below.

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COMPANY • ESTABLISHED 1816
NEW BRIGHTON, PENNSYLVANIA
Sales Offices in Principal Cities
Cherry Rivet Division • Santa Ana, California

In Canada: *Parmenter & Bulloch Manufacturing Company, Ltd., Gananoque, Ontario*

TOWNSEND COMPANY
Sales Department
New Brighton, Pa.

Please send Technical Sales Department Bulletin TL-98.

Name ____________________ Title ____________________
Company ____________________
Street ____________________
City ____________________ Zone ______ State ______

news of | ENGINEERS

R. P. Ganchan has been elec
vice president of Automotive Rub
Co., Inc.

Clarence Y. Robinson has b
named manager of Continental C
Co.'s metal can plant in Denver, a
John L. Tokich has been nam
manager of the company's m
can plant in Oakland, Calif.

Fritz Rosenthal has been nam
a plastics research chemist in
Armour Research Foundation's che
istry and chemical engineering de

Carrol L. Wilson, director
Industrial Development of the C
max Molybdenum Co., and for
general manager of the Ato
Energy Commission, has been elec
vice president and general mana
of Metals & Controls Corp.

news of | COMPANIES

Reichhold Chemicals, Inc.
moved its executive offices from
International Building in Rockefe
Center to its recently opened of
at 525 N. Broadway, White Plai
N. Y.

Robertshaw-Fulton Controls C
has announced that its new Ca
dian subsidiary has acquired a m
ern manufacturing plant in
Toronto area.

E. I. du Pont de Nemours
Co., Inc. has announced its pl
for a research laboratory devo
exclusively to industrial produ
To be known as the Industrial Pr
ucts Research Laboratory, it will
located at Newport, Del.

American Hard Rubber Co.
now making available high-pressu
compression and transfer-mold pa
of glass-reinforced plastics.

The Turner & Seymour Man
facturing Co. has announced t
purchase of the H & O Chain C
The complete H & O facilities ha
been transferred to the T & S pl
in Torrington, where its operatio
will continue as the H & O Div.
the Turner & Seymour Manufa
turing Co.

The Duplicon Co. has announc
the addition of a Sheet Plastic For
ing Dept.

General Electric Co. has a
nounced the formation of the Che
ical and Metallurgical Div. whi
includes the former Chemical D

(Continued on page 210)

◄ For more information, Circle No. 354

When you need

LARGE—HEAVY
and ACCURATE

Weldments

call on

STRUTHERS WELLS

Twin Turbine Gear Wheel for Westinghouse Electric Corporation

Of heavy steel throughout with a hollow bored steel hub made in our own forge plant.

Column Bearing Plates for Loewy-Hydropress, Incorporated, N.Y.C.

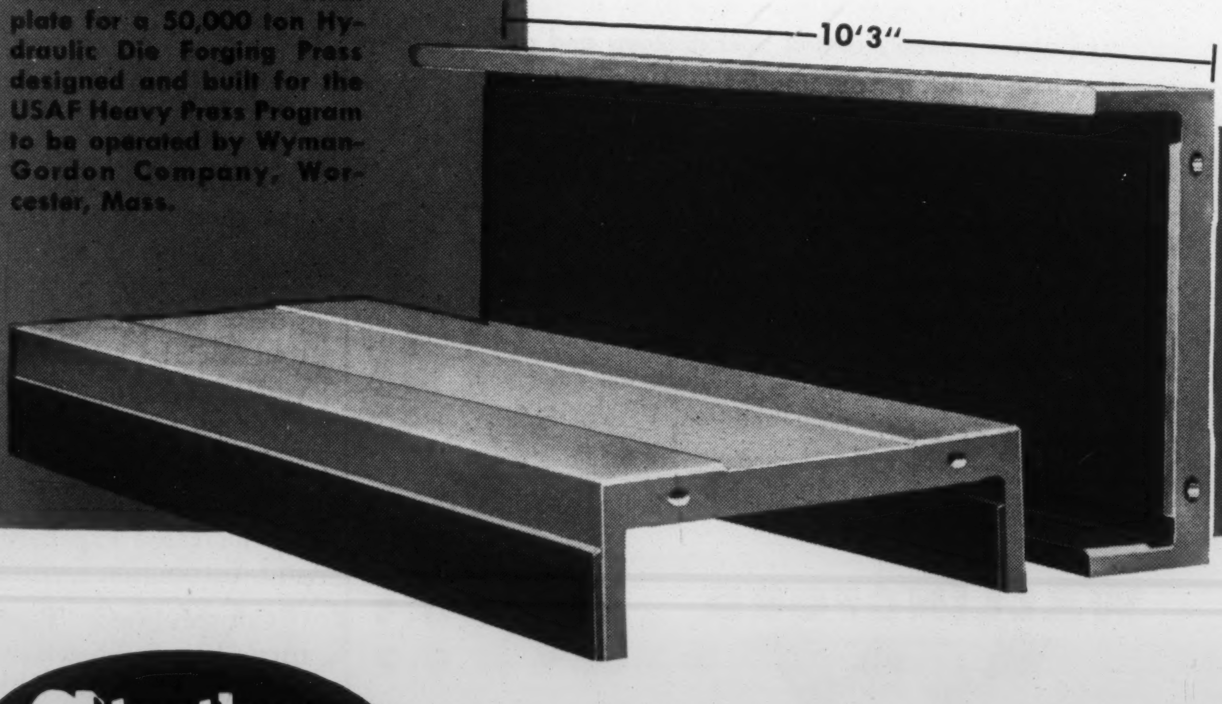
Welded of 3" and 5" thick plate for a 50,000 ton Hydraulic Die Forging Press designed and built for the USAF Heavy Press Program to be operated by Wyman-Gordon Company, Worcester, Mass.

The Gear Wheel and Bearing Plates illustrated typify Struthers Wells' manufacturing versatility.

The extensive facilities of three modern plants plus a century of experience are at your service.

We welcome the opportunity of furnishing either the complete assembly or any weldment part that is beyond your capacity.

Write for Weldments bulletin.

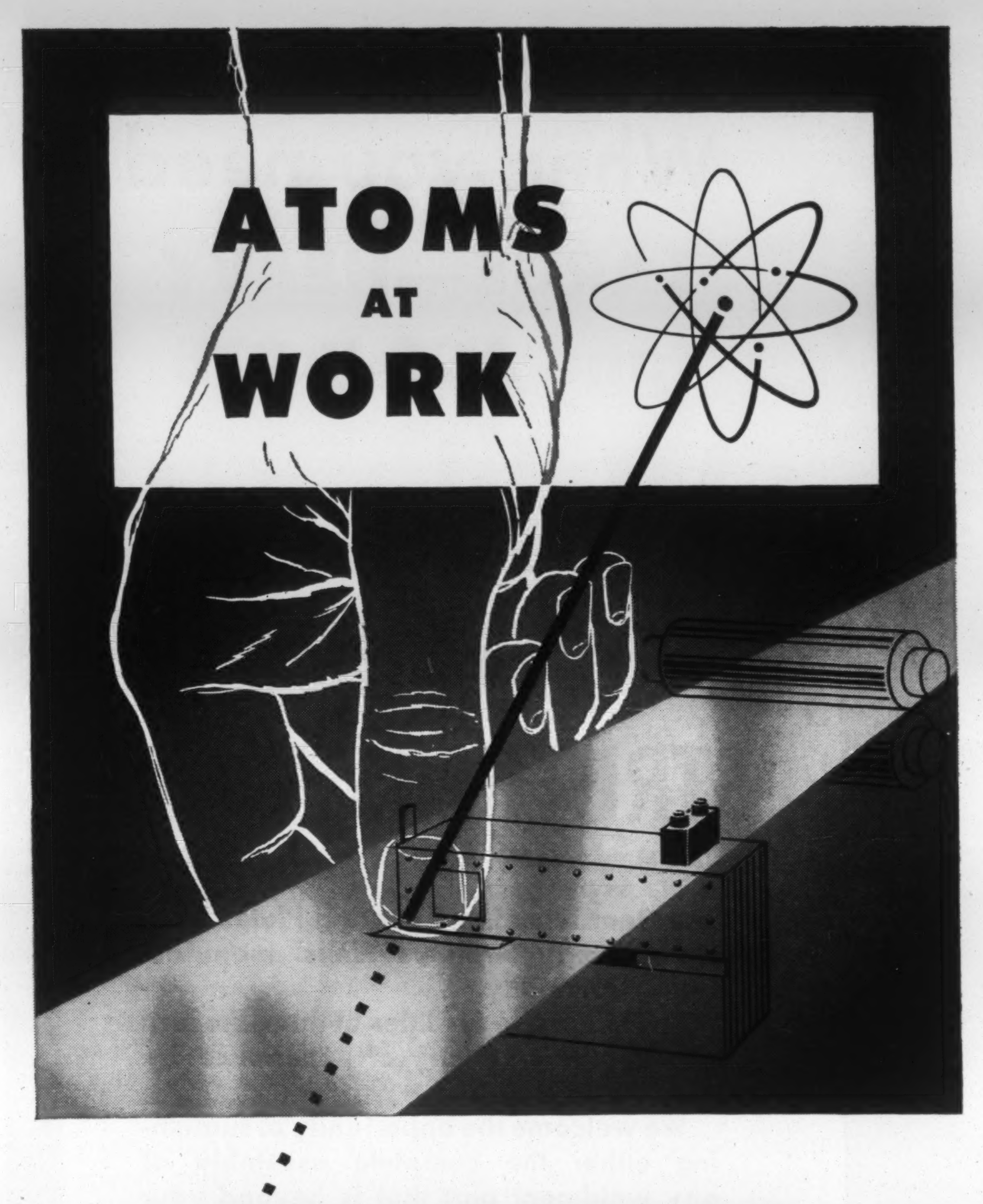


Forty of these 8900 lb. bearing plates were supplied for the 50,000 ton Hydraulic Die Forging Press. Dimensions were 45" wide x 15" high x 10'3" long.

Struthers Wells

STRUTHERS WELLS CORPORATION
Titusville, Pennsylvania
Plants at Titusville, Pa. and Warren, Pa.

For more information, turn to Reader Service Card, Circle No. 431



AT WALLINGFORD STEEL

At Wallingford, harnessed atoms precisely control steel thickness and assure important improvement in uniformity . . . ***automatically.*** Here, radioactive isotopes of strontium or ruthenium demonstrate their superiority over mere man. Electronic continuous gages check strip, ranging down to .002" and to tolerances as close as .0001", without touching the metal to mark or otherwise affect it. ***Man alone is unable to control steel thickness so accurately . . . so fast!***

This practical application of atomic energy to improve our quality control is another reason why you can be confident that Wallingford will meet your most rigid specifications for stainless steel strip and tubing ***exactly*** . . . another reason for arranging to use Wallingford's ultra-modern facilities ***soon.***

THE
WALLINGFORD
SINCE 1922
STEEL
CO.
WALLINGFORD, CONN., U. S. A.

STAINLESS • ALLOY • HIGH CARBON • LOW CARBON • STRIP AND TUBING

For more information, turn to Reader Service Card, Circle No. 367

news of | COMPANIES

and the Carboloy Dept. Robert L. Gibson has been appointed general manager of the division. Under the new organization arrangement, the former Chemical Div.'s four operating departments will not change.

American Can Co. is planning a multi-million-dollar expansion program which will double the capacity of its St. Paul, Minn., plant.

Sub-Zero Products Co. has announced a change in its name to Cincinnati Sub-Zero Products Co.

General Electric Co.'s Chemical Materials Dept. has announced the establishment of new experimental shell molding foundry, with complete facilities for making shell molds and pouring castings.

Alsynite Co. of America has opened its third manufacturing plant, in Paterson, N. J.

Packard Motor Car Co. has announced that final car assembly operations will be moved into a new modern single-story plant this fall in Detroit.

Federal Electric Products Co. has changed its name to Federal Pacific Electric Co., following the merger of Federal Electric Products with its wholly owned subsidiary, Pacific Electric Manufacturing Corp.

Carboline Co. has announced the formation of an Adhesives Div. The new division will specialize in research and development of adhesive products for specific uses.

United-Carr Fastener Corp. has announced the acquisition of all of the capital stock of the Palnut Co.

Alloy Precision Castings Co. has announced that it has leased the entire plant of the Industrial Metal Castings Corp., a wholly owned subsidiary of the Mercast Corp. Industrial Metal Casting Corp.'s facilities will be known as Plant 2 of Alloy Precision Castings Co. and is located at 13721 Bennington, in Cleveland.

The Atlas Mineral Products Co. has increased expansion of its plant and distribution facilities.

Consolidated Testing Laboratory, Inc., affiliated with Industrial X-Ray, Inc., and Able Laboratory, Inc., has recently opened its facilities for all phases of chemical, spectrochemical and metallurgical testing at 164 Cherry Valley Road, West Hempstead, N.Y.

(Continued on page 212)

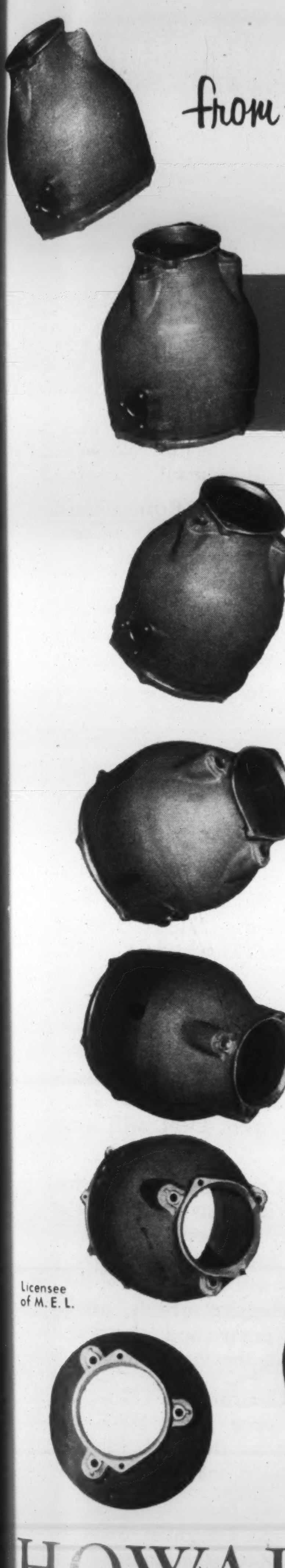
from the worlds largest magnesium jobbing foundry…

Magnesium Alloys

Guaranteed

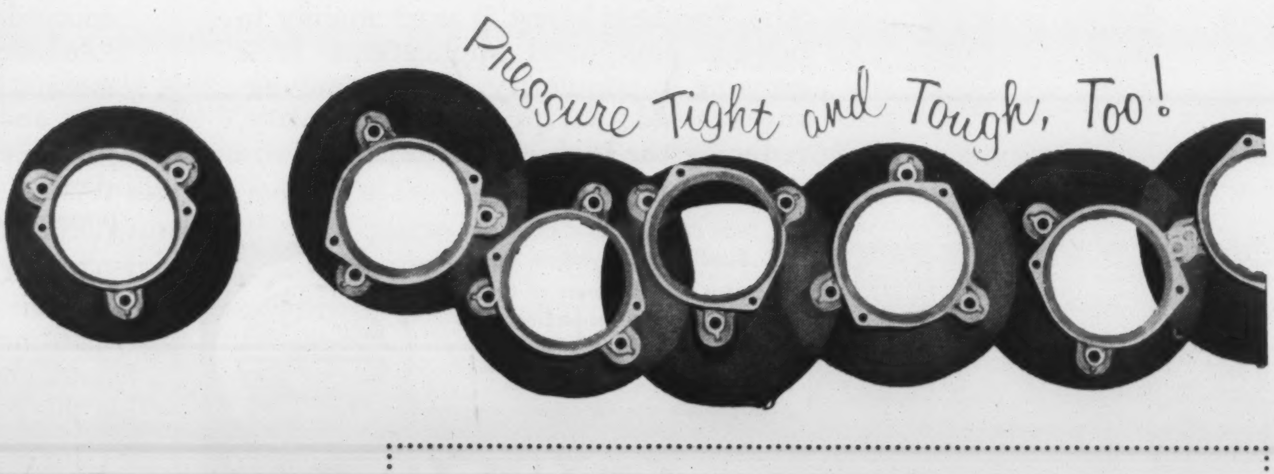
PRESSURE TIGHT

without impregnation



Are you getting sand molded pressure tight parts through impregnation? If you are then you'll be interested in Howard's ZRE1 and ZT1 magnesium alloys. We guarantee these alloys pressure tight at both room and elevated temperatures—*and they require no impregnation!* The operating temperature of ZRE1 is up to 500° F., while ZT1 is up to 650° F., highest temperature magnesium alloy available. These alloys—first supplied to U. S. industry by Howard—are currently being used in hydraulic units, fuel tees, fuel elbows, sump housings, gear housings and many other parts requiring pressure tightness. To find out how you may use pressure tight magnesium—world's lightest structural metal—write for information. Or, ask to have your local Howard representative call.

"PRESSURE TIGHT" EXAMPLE: Shown here is a jet engine's combustion chamber cover (14½" high, O. D. 13"). It is sand molded of Howard's ZRE1 magnesium alloy and must withstand operating temperatures up to 500° F. and 300 lbs. p. s. i. pressure test. Casting is not impregnated yet wall thickness is only 3/16" in as cast and aged condition.



Licensee
of M. E. L.

HOWARD FOUNDRY COMPANY

General offices:
1702 North Kostner Avenue • Chicago 39, Illinois
Plants at:
Chicago • Los Angeles • Milwaukee
WE LIKE TO BE KNOWN BY THE CUSTOMERS WE KEEP

a famous foundry name for 41 years

CASTINGS AND PATTERNS

SAND MOLD • PERMANENT MOLD • INVESTMENT CASTING

WOOD & METAL PATTERNS • METAL DIES • WAX • PLASTIC

Materials: Aluminum • Magnesium • Brass • Bronze • Beryllium Copper • Copper • Gray Iron • Ductile Iron • Ni-Resist • Ductile Ni-Resist Ni-Hard • Alloy Steel • Carbon Steel • Stainless Steel • Titanium

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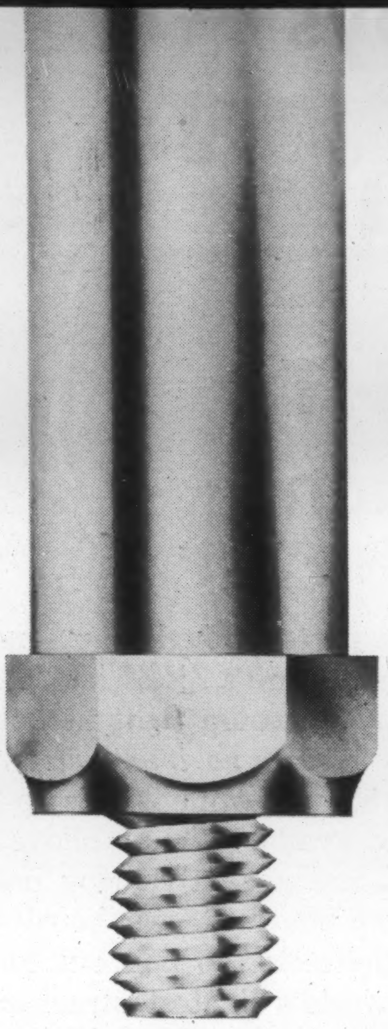
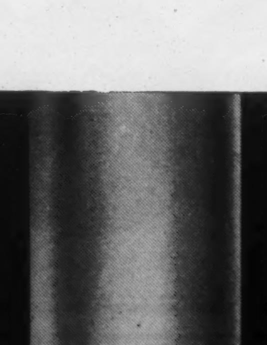
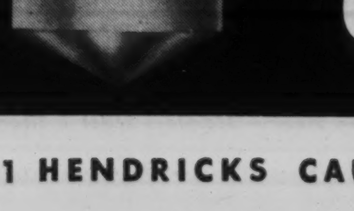






TAP-LOK INSERTS*
save time because—

only ONE tool is needed—

- √ no separate tapping operation
- √ no fussy hole preparation
- √ no crossing of threads possible
- √ no secondary staking required

Tap-Lok Inserts are the answer to your thread fastening problems. Tap-Lok installation is as fast and easy as tapping a thread. A simple driving tool with a hardened threaded shoulder stud engages the internal thread of the insert and, as the insert is its own tap, it simply taps its way into a cored or drilled hole. Where staking is desired, the driver shoulder performs this operation at the same time the insert is seated. Production line installations of the Tap-Lok Insert are readily made by means of a standard tapping attachment on a drill press.

◀ **THE TAP-LOK INSERT** retains its seat firmly in the boss material as a result of a friction lock it obtains by cutting its own thread. It is not subject to the time-consuming failures of molded-in and cast-in inserts.
The Tap-Lok Insert is used mainly in original equipment applications. It is growing in popularity, also, for salvaging threads stripped in assembly, reducing the high cost of rejects.

Send for descriptive folder. Also manufacturers of Groov-Pins for positive-locking press fit.

*Reg. U. S. Pat. Off.

GROOV-PIN CORPORATION

1121 HENDRICKS CAUSEWAY, RIDGEFIELD, N. J.

For more information, turn to Reader Service Card, Circle No. 483

news of | COMPANIES

National Lead Co. will begin construction of new facilities for the production of titanium dioxide at St. Louis.

Pennsylvania Salt Manufacturing Co. will construct two new plants, one at Delaware, Ohio and one at Chicago Heights, Ill.

The Newton Co. has purchased the machinery and equipment of American Tool Works. The facilities will be removed from their present location to Newton Co.'s plant in Manchester, Conn.

Roto-Finish Co. announces a new plant addition to expedite deliveries and improve manufacturing facilities. The new facilities will be devoted entirely to new machinery and equipment for manufacturing grinding chips and compound.

E. I. du Pont de Nemours & Co. has announced a project to expand facilities for the manufacture of Teflon. It will about double present capacity for making Teflon at the company's Washington Works near Parkersburg, W. Va.

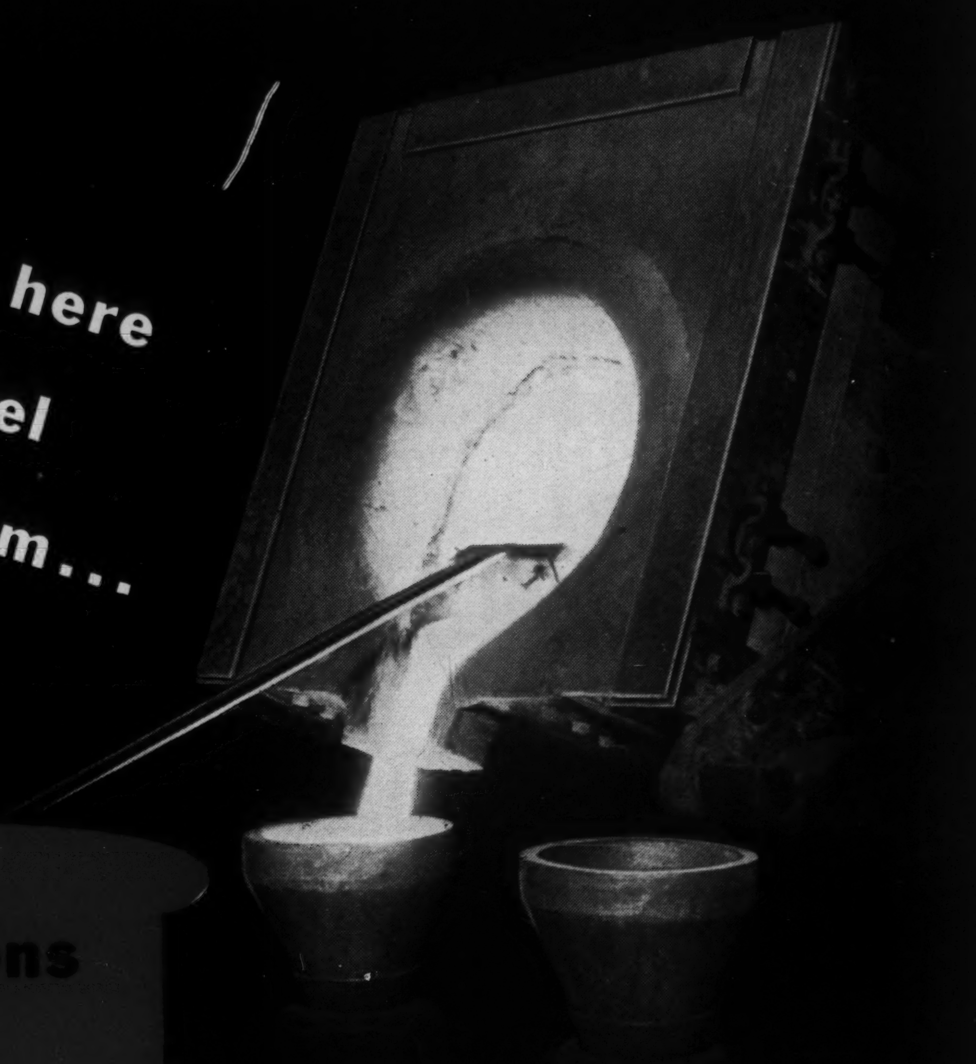
General Electric Co. has announced the formation of two new organizations, a Meter Dept. and an Instrument Department. An additional step in the company's decentralization program, the move divides the former Meter and Instrument Dept. into two separate units. The Meter Dept. will make its headquarters at Somersworth, N. H., while the Instrument Dept. will remain in Lynn.

The Carborundum Co. has announced its plans to establish a new subsidiary in Puerto Rico which will manufacture bonded abrasive products, and sell a full line of the company's abrasive wheels, sandpaper, abrasive grains and electrical components in the Puerto Rican market.

The Chemstrand Corp., in production since Dec., 1953, is now operating as the first wholly integrated nylon manufacturing facility in this country.

Jones & Laughlin Steel Corp. has announced that construction has already started on its new research center which is located on Baldwin Hill, on the south side, 400 feet above the Monongahela, overlooking J&L's Pittsburgh Works.

Pittsburgh Plate Glass Co. has moved its entire New York office from 30 Rockefeller Plaza to an en-



Starting here it's mostly nickel and chromium...

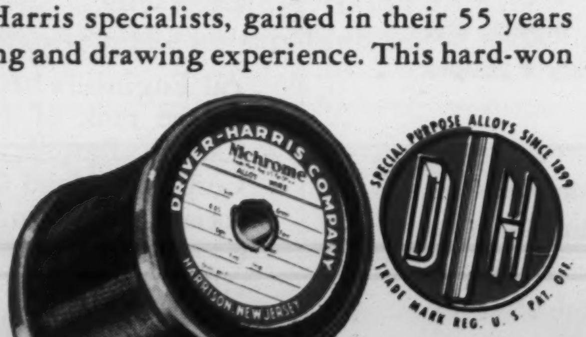
127 operations later, it's

Nichrome*

There are several excellent nickel-chrome combinations on the market. But there is only one Nichrome*.

What is it that makes this alloy the universal standard by which engineers judge the properties of heat and corrosion resistance? There is always at least one extra ingredient added to the nickel and chrome. That is . . . the supreme mastery of the Driver-Harris specialists, gained in their 55 years of melting and drawing experience. This hard-won skill of theirs is reflected in improved heating and quenching techniques . . . in specially developed deoxidizing anneals . . . in expert and precise control of every technical process of the entire manufacturing cycle. Sometimes, indeed, there are as many as 127 distinct operations between melting crucible and the finished wire, strip, or rod.

In recognition of its unique properties, the United States Patent Office in August, 1908, granted solely and exclusively to us the trademark NICHROME. There is only one Nichrome, and it is produced by Driver-Harris.


DRIVER-HARRIS COMPANY
Nichrome
HARRISON NEW JERSEY
SPECIAL PURPOSE ALLOYS SINCE 1899
D/H
TRADE MARK REG. U. S. PAT. OFF.

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Louisville.
Los Angeles, San Francisco

In Canada: The B. GREENING WIRE COMPANY, Ltd., Hamilton, Ontario.

MAKERS OF THE MOST COMPLETE LINE OF ELECTRIC HEATING, RESISTANCE, AND ELECTRONIC ALLOYS IN THE WORLD

VISIT DRIVER-HARRIS AT THE PHILADELPHIA INSTRUMENT SHOW BOOTHS 559-561

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automatic protection
or control
for your
heating process
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1000
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Alnor
PYROTAC

Here's a simple, low-cost way to obtain *AUTOMATIC PROTECTION* against damage due to excessive temperatures... safeguard your investment in heating equipment and materials in process. This precision-built instrument constantly indicates temperature of the heated equipment and sounds an alarm and/or shuts down the heated circuit at a safe, pre-set temperature. It may also be used as a *CONTROLLER* on a process requiring shutdown upon reaching a final process temperature—such as ceramic kilns, molds, etc. Automatic thermocouple break protection assures safety if couple or extension wires should break.

Ask your Alnor representative for details on this sturdy, precise instrument. You'll find the price of less than a hundred dollars unusual for an instrument of this type. Write for bulletin that contains complete description and wiring diagrams of actual applications. Illinois Testing Laboratories, Inc., Room 522, 420 N. LaSalle Street, Chicago 10, Ill.

Alnor

ILLINOIS TESTING LABORATORIES
PRECISION INSTRUMENTS FOR EVERY INDUSTRY

For more information, turn to Reader Service Card, Circle No. 363

tire floor of a recently completed office building at 579 Fifth Ave., New York.

Stillman Rubber Co. is now offering polyvinyl products for industrial use which are available from its new Polyvinyl Div.

News of Societies

The **Drop Forging Association**, at its 19th Annual Meeting recently held in Hot Springs, Va., elected K. E. Walter, president, The Alliance Drop Forging Co., as its president. Charles W. Stone, vice president, Interstate Drop Forge Co., was elected vice president.

Alloy Casting Institute at its recent 14th Annual Meeting, elected C. K. Lockwood, vice president, the Stainless Steel & Alloys Div., Shawinigan Chemicals Ltd., as president. Thomas Rutherford, The Midvale Co., was elected to the office of vice president of the Institute.

The **American Society of Tool Engineers** has chartered three new chapters which increases the Society's total number of chapters in the United States and Canada to 118. The three chapters receiving charters are Kalamazoo and Battle Creek, Mich., and Southeastern Massachusetts.

The **American Society of Heating and Ventilating Engineers** has announced the appointment of Elmer R. Kaiser as its new director of research. Mr. Kaiser has been actively engaged in research work and during the past twenty years has served on the staff of Battelle Memorial Institute, and with Bituminous Coal Research as an assistant to the president, assistant director of research, general manager of B.C.R. Products, Inc., and associate director of research in charge of the B.C.R. Laboratory.

American Society of Mechanical Engineers has elevated four men to the rank of Fellow. They are: Carroll Russell Alden, Ex-Cello-Corp.; Raymond Charles Burton, associate supervising engineer, United Engineers and Constructors, Inc.; Alfred G. Hoppe, mechanical engineer with the Chicago, Milwaukee, St. Paul and Pacific Railroad Co., and Walter C. Lindemann, A. J. Lindemann and Hoverson Co.

Denison Engineering Co. has announced the establishment of the Aircraft Products Div. Edwin L. Shaw has been appointed to head the

Now... Machining
and Heat Treating
In One Operation!

with TOCCO Induction Heating

Mechanics Universal Joint Division of Borg-Warner Corporation now combines automatic heat-treating and metal-working operations on the same machine!*

A Tocco Inductor Coil, matched to one spindle of a multiple spindle automatic screw machine, heat treats the inside diameter of automotive trunnion cups—after they have been completely formed on the same machine tool. Twenty-two, 20 and 50 kw, 450,000 cycle TOCCOtron Induction Heating units and 44 automatic screw machines (installed here and in other plants) make up this high-speed production team.

This new method permits the use of SAE 1144 steel and eliminates costly, time-consuming copper plating and carburizing operations formerly required. Heating and quenching cycles total approximately 10 seconds per part, and production is in excess of 300 parts per hour from each machine.

If your products or their components require heat treating, soldering, brazing or forging it will pay you to investigate TOCCO for better, faster ways of producing them at lower unit cost.

*A patented process.

THE OHIO CRANKSHAFT COMPANY

JUST PUSH A BUTTON

TOCCO

*Trade Mark Reg. U. S. Pat. Off.

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NEW FREE BULLETIN

THE OHIO CRANKSHAFT CO.
Dept. T-9, Cleveland 1, Ohio

Please send copy of "Typical Results of TOCCO Induction Hardening and Heat Treating."

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City________ Zone____ State________

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How Much

Excess Weight

in Your Product?

Trim it down to "fighting weight" with stampings by GEOMETRIC

The cost of your product is largely determined on the drawing board. Whenever you use castings or forgings as component parts, where stampings would do as well, you increase the weight and cost of your product unnecessarily.

Many progressive manufacturers have cut the cost of component parts up to 75% by converting from castings to stampings. Savings of 50% are common.

Geometric Engineers, trained in the analysis of all kinds of stamping problems, are glad to show you how your product, or parts of it, can be made better, lighter and at much lower cost in our modern high-production stamping plant.

Write today for free booklet — "Geometric Craftsmanship"

GEOMETRIC STAMPING CO.
A Subsidiary of Barium Steel Corp.
1145 E. 200th Street
Cleveland 17, Ohio

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news of | COMPANIES

new division, and James Parr has been named as chief engineer.

H. K. Porter Co., Inc. has acquired **Pioneer Rubber Mills, Inc.**, Pittsburgh, Calif. The new acquisition will become part of the **Quaker Rubber Corp.**, one of H. K. Porter Co.'s nine divisions.

R. M. Hollingshead Corp. has announced construction of a new branch in Sunnyvale, Calif. Occupyin a 10-acre site on Kifer Rd., it is expected that the new plant will be in operation by Jan. 1, 1955.

American Car & Foundry Co. has established two new engineering departments, Advanced Development Engineering and Buffalo Product Engineering, to replace the former Engineering Dept. at the company's Buffalo plant. Robert L. Holloway, formerly chief engineer of the Buffalo plant, has been named chief engineer of the Advanced Engineering Dept., and Herbert E. Oles, formerly section manager of product engineering of the former engineering department in Buffalo and been made chief engineer of the Buffalo Product Engineering Dept.

Shell Chemical Corp. and **Lac Chemicals, Inc.** have announced jointly a transaction under which Shell is to acquire the major physical assets of the Lac firm.

Vapor Heating Corp. has moved manufacturing operations and general offices into its new plant in Niles, a suburb of Chicago.

Battelle Memorial Institute has purchased a 397-acre plot of land 15 miles west of downtown Columbus. The new acreage is needed because of newly developed opportunity for Battelle to engage in more large-scale experimental projects.

American Car and Foundry Co. has changed its corporate name to ACF Industries, Inc.

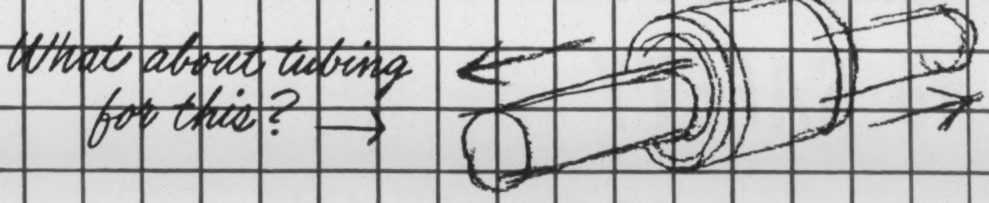
Steel Improvement and Forge Co. has purchased the Champion Forge Div. of **Champion Industries, Inc.**

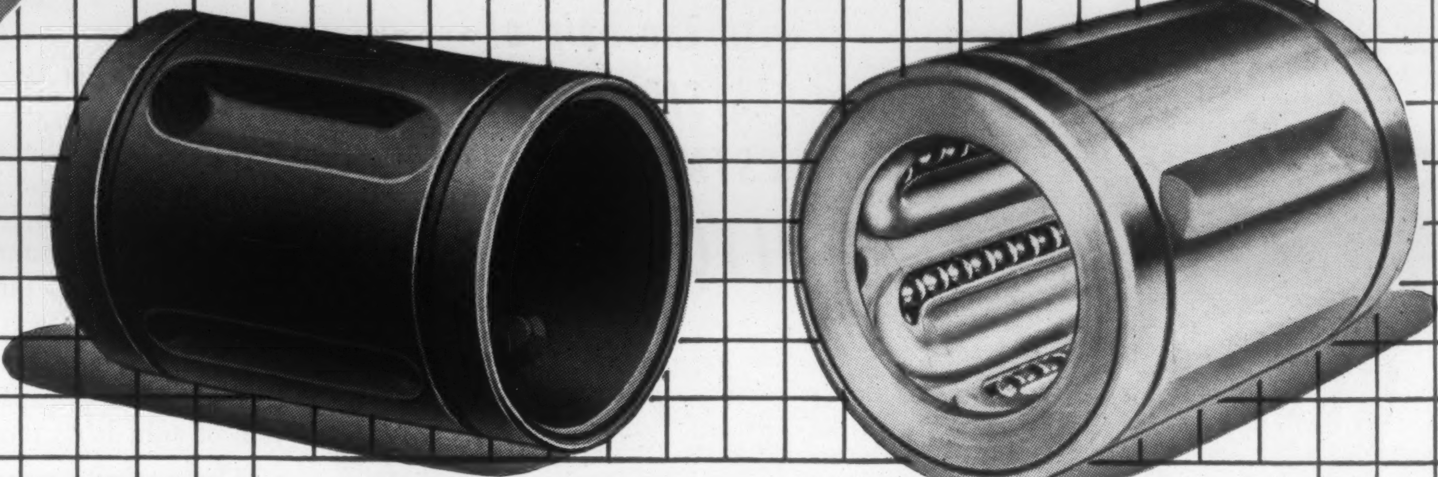
The **Richardson Co.,** formerly located at Wyoming and Cooper Aves., Lockland, Cincinnati, is now located at 27th & Lake St., Melrose Park, Ill.

Allmetal Screw Products Co., Inc. recently celebrated its twenty-fifth anniversary and the completion of its Garden City plant.

(Continued on page 218)

This started with a doodle


What about tubing for this?



Precision Tubing for Precision Jobs

Tubing tolerance is a big "must" on this job. Thomson Industries, Manhasset, N.Y., insists on it. Otherwise, manufacturing BALL BUSHINGS (ball bearings for linear motion) would have been even tougher than it was.

Part of the problem was the tubing to house the bearings and the raceway. Those bearings are very tough on tubing . . . especially at the contact points.

Other requirements were: good surface conditions; good dimensional control, both I.D. and O.D.; uniform wall thickness; uniform concentricity; and uniformity from a metallurgical standpoint to stand heat treating.

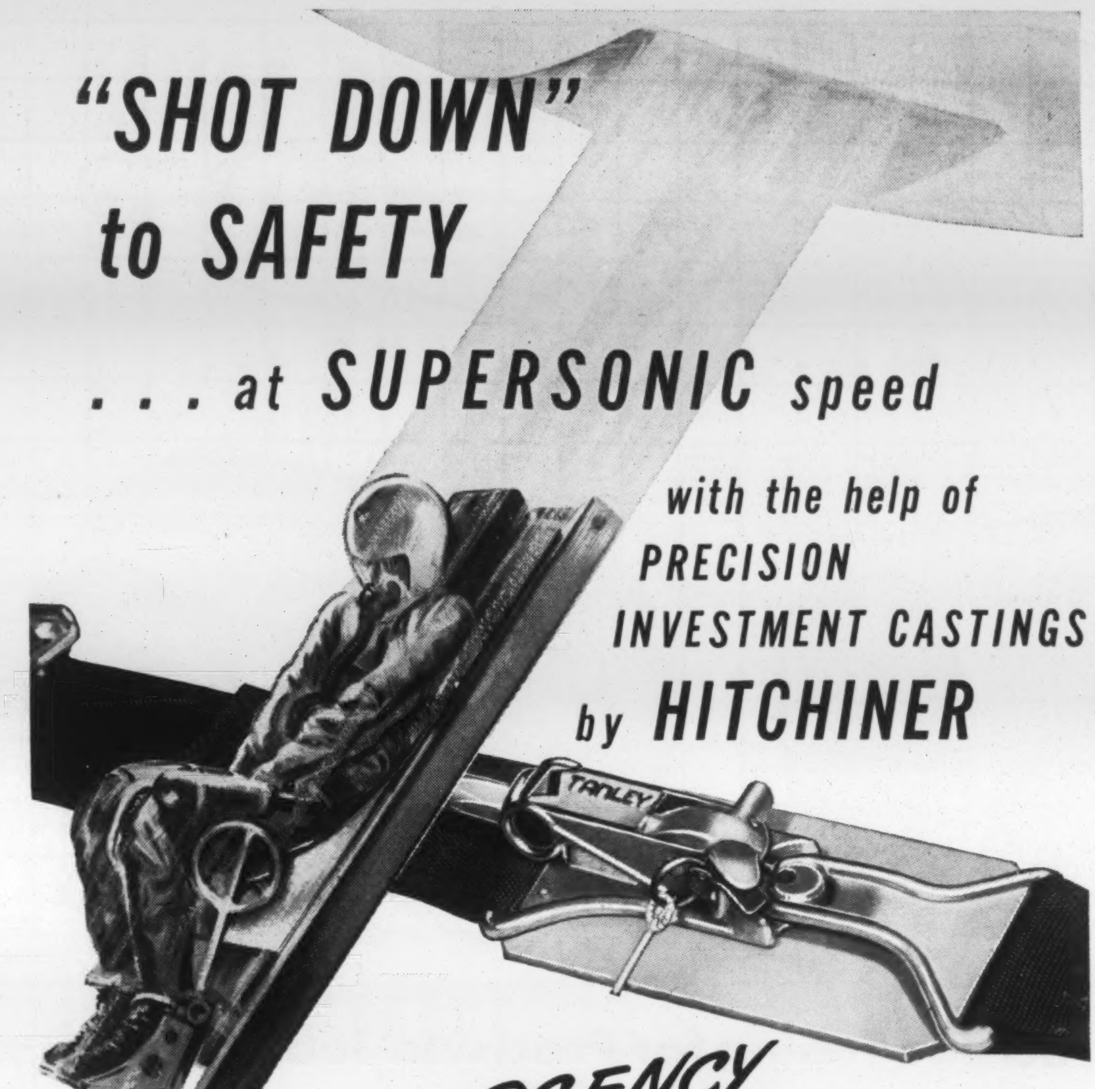
And, equally important, economy. By using ELECTRUNITE Tubing, Thomson Industries eliminates a grinding operation. That helps keep costs down.

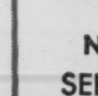
The tubing that has all these advantages is Republic ELECTRUNITE, a *precision* mechanical tubing for applications like this. You can get it in carbon or stainless analyses. And Republic engineers will be glad to help you use it, profitably, in whatever products you make. Call your nearest Republic Sales Office or write to:

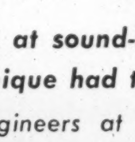
REPUBLIC STEEL CORPORATION
Steel and Tubes Division
218 East 131st Street, Cleveland 8, Ohio
GENERAL OFFICES • CLEVELAND 1, OHIO
Export Department: Chrysler Building, New York 17, New York

REPUBLIC
ELECTRUNITE TUBING

For more information, turn to Reader Service Card, Circle No. 347







"SHOT DOWN" to SAFETY

. . . at SUPERSONIC speed

with the help of PRECISION INVESTMENT CASTINGS by HITCHINER

EMERGENCY BAIL OUT!

And at sound-barrier speeds, a revolutionary bailout technique had to be found.

So engineers at Stanley Aviation Corp., Buffalo, N.Y., developed an ejection seat that catapults **downward** from a plane and a lap belt that automatically opens, frees the airman from the seat, and sequences parachute opening.

The cost of this priceless protection? Slashed to a minimum through the use of HITCHINER Precision Investment Castings. By combining several small parts into one . . . building complex shapes without added machining . . . using beryllium copper and stainless steel, HITCHINER achieved lower total production costs plus lighter weight with extra strength — economies and design achievements not possible with other production methods.

For a new approach — the logical solution to **your** small parts problems — consult HITCHINER. Send us your drawings. Mail the coupon for informative FREE booklet.

HITCHINER
Manufacturing Co., Inc.
MILFORD,
NEW HAMPSHIRE
SEE US AT BOOTH
1412
NATIONAL METAL
EXPOSITION
NOV. 1-5, CHICAGO

HITCHINER MFG. CO., INC.
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☐ Send me your FREE booklet, "Investment For Economy . . . For Performance."
☐ Have your representative call.
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CITY________ZONE________STATE________

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news of | COMPANIES

Lustro Plastic Products has moved to new quarters at 1066 Home Ave., Akron, Ohio.

Kaiser Aluminum & Chemical Corp. has announced a $1,500,000 program for expansion of its aluminum and sheet rolling and finishing facilities at its Trentwood Works.

Calresin Corp. has moved to new quarters at 4543 Brazil St., Los Angeles 39.

Aluminum Ltd. has announced completion of important new extensions to the research facilities of its subsidiary, Aluminum Laboratories, Ltd., at Banbury, England.

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(Continued on page 220)

It's welded—
but you can't feel the weld

It has to be accurate

It's easy to
fabricate

Specify Brainard FOR WELDED STEEL TUBING

● Brainard welded tubing is an economical structural material, and offers many physical advantages. It has a smooth exterior, with all weld flash removed. Its wall thickness is uniform, since it is formed from flat strip. With welded tubing you can cut weight without sacrificing strength. And there's practically no limit to the design requirements you can meet with this easily fabricated material.

Brainard maintains continuous quality control throughout manufacture—from ore to finished tubing. Careful supervision assures you high quality. For complete specifications call or write Brainard Steel Division, Dept. X-9, Griswold St., Warren, O.

Brainard
SHARONSTEEL
STEEL DIVISION
SHARON STEEL CORPORATION

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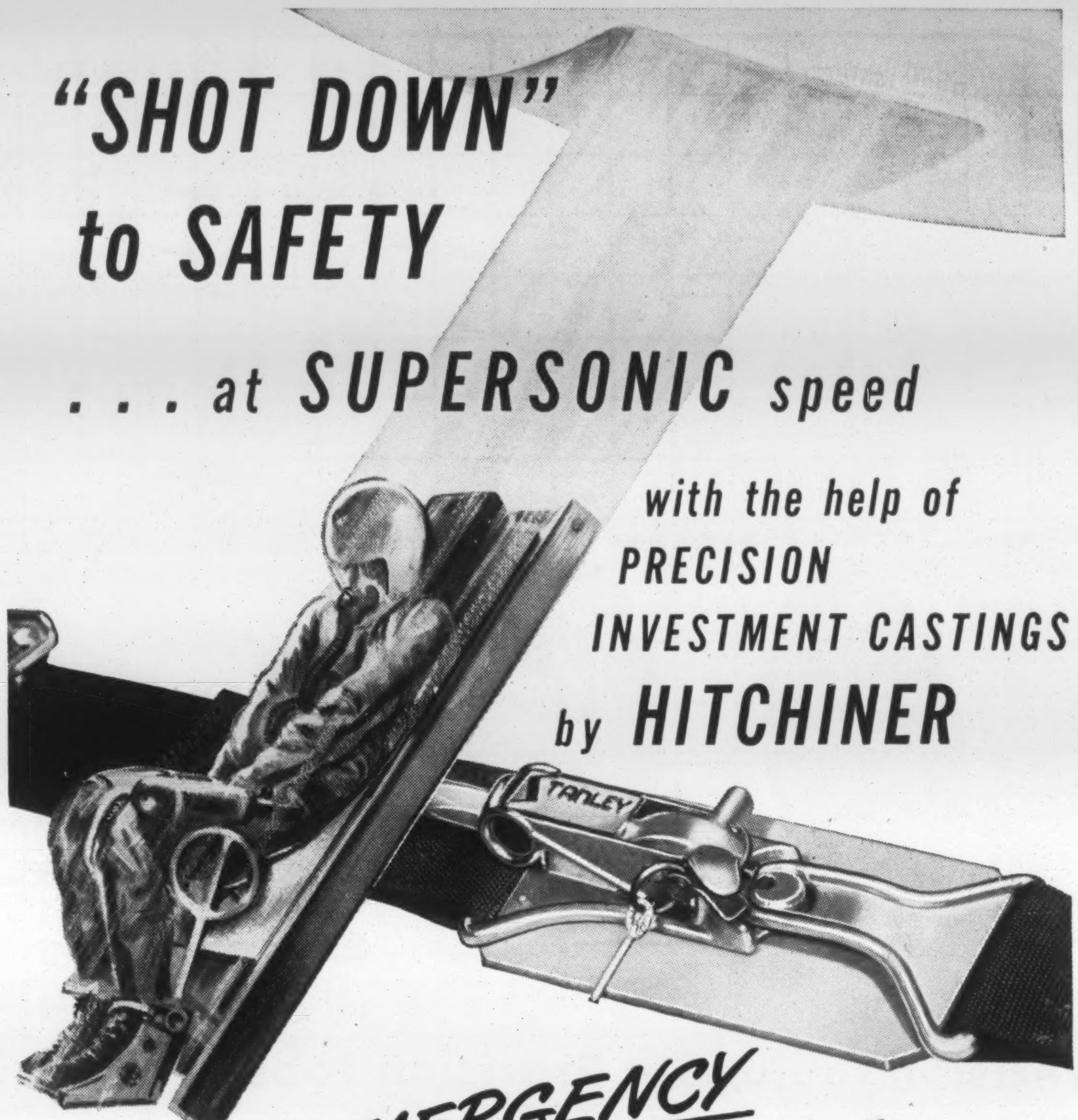
"SHOT DOWN" to SAFETY

. . . at SUPERSONIC speed

with the help of PRECISION INVESTMENT CASTINGS by HITCHINER



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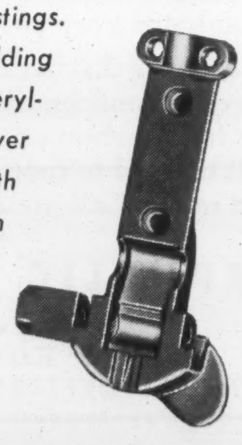

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NATIONAL METAL EXPOSITION
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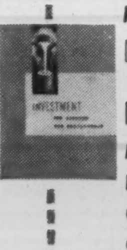

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SHARON STEEL CORPORATION

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ATLANTALLOY
PLASTER MOLD CASTINGS CAN SOLVE YOUR DESIGN PROBLEMS

Atlantalloy plaster mold precision castings provide non-ferrous castings *cast to ordinary machining tolerances*, effecting definite savings in machining and other costly operations. Atlantalloys are characterized by high strength, durability, and many other advantages.

NO. 10 YELLOW BRASS *Atlantalloy* — An all-purpose alloy for brush boxes, gears, levers, etc. Fine grain, clean, smooth surfaces assure tightness. Easily machined. Free from porosity. Fatigue resistant.

NO. 20 ALUMINUM BRONZE *Atlantalloy* — Excellent for gears and bearings. Strong, light, zinc-free. Highly resistant to corrosion. Machines well.

NO. 31 *High Tensile* MANGANESE BRONZE *Atlantalloy* — High strength engineering material for gears, valve bodies, electrical mechanisms, etc. Extremely durable. No heat treatment needed. Can be cast in thin sections.

NO. 40 *High Strength* ALUMINUM *"Tenzalloy"* — Attains high strength through natural aging. Free from internal stress and skin hardness. Ideal for machining.

NO. 60 ALUMINUM *Atlantalloy* — Perfect as instrument alloy. Fully uniform with no internal strain. Can be used for accurate, thin-sectioned castings.

WRITE... for free copy of "Quality Precision Castings for Industry." Get full data on our plaster mold process and alloys.

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news of | SOCIETIES

The American Welding Society has selected as the best student paper on welding to appear in an undergraduate publication during the year ending June 1, 1954, "Underwater Metallic Arc Welding," by O. P. Eberlein and R. C. Waugh. The authors of the paper will split a cash award of $200. *The Cornell Engineer,* which published the paper in its May, 1954 issue, will receive an award of $200. A second prize of $100 was received by Richard Hayes of M.I.T. for his article "Recent Ship Failure Studies." This article appeared in the March, 1954 issue of *Tech Engineering News* and that magazine will receive $100 for publishing the prize winning entry.

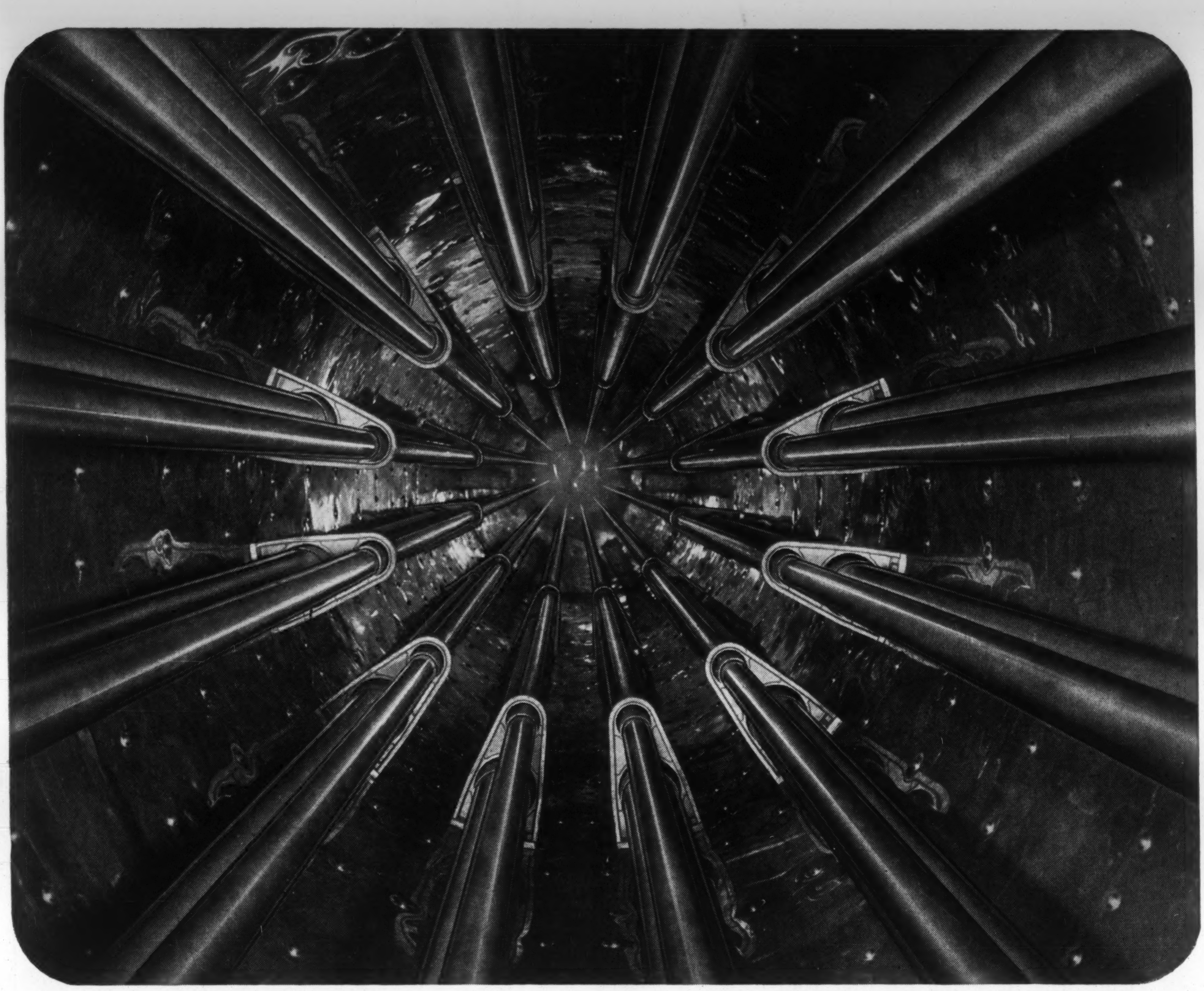
American Electroplaters' Society has elected Dr. Ralph A. Schaefer, vice president, The Clevite-Brush Development Co., as its president. Clyde Kelly, American Plating Co., was elected first vice president; Dr. Samuel Heiman, chief chemist and technical director, Philadelphia Rustproof Co., becomes second vice president; and Francis T. Eddy, assistant plant superintendent, Chase Brass & Copper Co., was elected third vice president.

The **American Society of Mechanical Engineers** has announced the nomination of David W. R. Morgan, vice president on the headquarters staff of Westinghouse Electric Corp., to serve as the next president of the Society.

The **Institute of the Aeronautical Sciences** announced at its recent meeting held in Los Angeles, the establishment of an IAS Fellowship in Flight Test Engineering. Also announced at the meeting, was the establishment of the Minta Martin Aeronautical Student Fund.

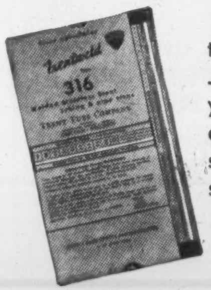
(Meetings and Expositions on page 222)

Now
U.S. DEFENSE BONDS
EVEN BETTER



TRENTWELD STAINLESS TUBING

gives longer operating life...



FREE—Write for your copy of the new TRENTWELD price calculator. Just a tug at the selector slide gives you complete price information and weight per foot of the tubing size and grade you need. Better send for your free copy now.

TRENTWELD stainless steel tubing gives economical, trouble-free service over long periods of use. It's an ideal choice, for example, for applications such as the 60-foot rotary kiln dryer you are looking into in the photograph above . . . operating at high temperatures and where corrosive conditions are encountered.

In fact, you just can't buy better tubing than TRENTWELD for any application. That's because TRENTWELD stainless and high-alloy *welded* tubing is a product of tube mill specialists. Each tube has a uniformly sound weld indistinguishable from the parent metal and just as strong and corrosion-resistant.

Whether or not your job is as large and complex as a rotary dryer, you can specify TRENTWELD tubing with confidence. And when it comes to tubing sizes and finishes, Trent offers the widest range in the industry . . . from 1/8″ to 40″ O.D. and up. Next time you have a job involving tubing, remember—you can make it better with TRENTWELD.

Join your Civil Defense Team NOW!

TRENTWELD

STAINLESS STEEL TUBING

TRENT TUBE COMPANY, GENERAL SALES OFFICES, EAST TROY, WISCONSIN (Subsidiary of CRUCIBLE STEEL COMPANY OF AMERICA)

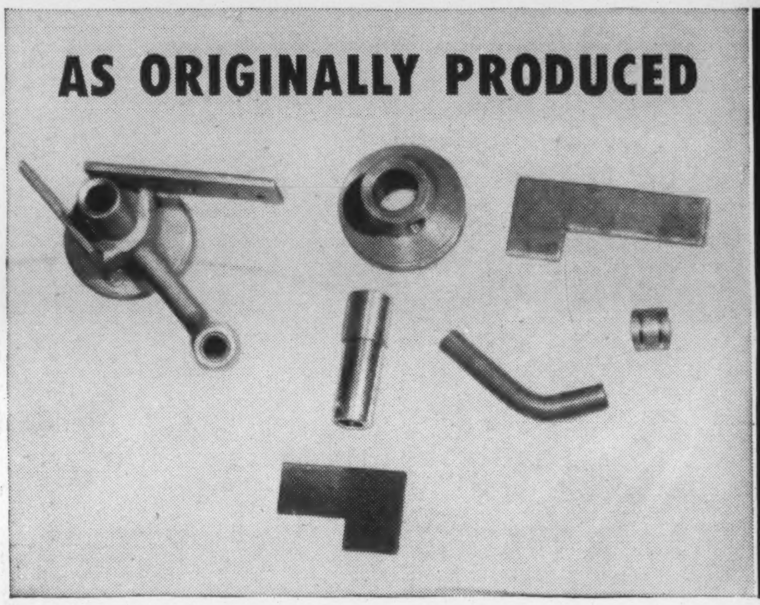
For more information, turn to Reader Service Card, Circle No. 457

AS PRECISION CAST...

$4.90

AS ORIGINALLY PRODUCED

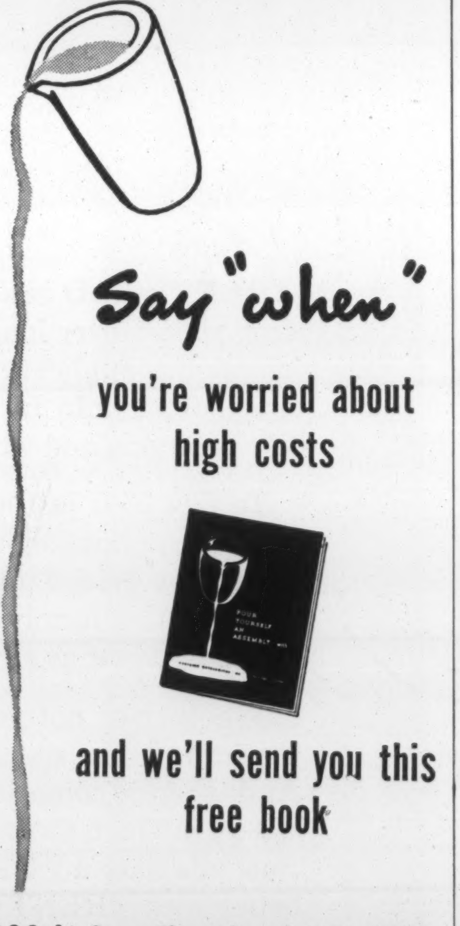
$?.00



Precision Metalsmiths casts this valve as a pressure-tight unit in a beryllium copper alloy at the unbelievably low cost of $4.90.

Figure what it would cost—at your overhead—to produce, handle and stock the six brass, copper and steel parts that formerly went into this assembly. Then add fabrication costs, with an allowance for leaker-rejects that showed up all too frequently.

We can't promise you savings like this, of course. But the expendable pattern process gives product designers a free rein; your men *imagine* what they'd like to have and we cast it for them. Many machining and assembly operations can be eliminated and, often, parts are made in alloys that can't be machined—a fraction of an ounce up to 10 pounds.


Say "when"
you're worried about high costs
and we'll send you this free book

PRECISION METALSMITHS, INC., 1081 East 200th St., Cleveland 17, Ohio

pour yourself an assembly with
PRECISION METALSMITHS INC.
INVESTMENT CASTINGS

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Meetings and Expositions

SOCIETY FOR EXPERIMENTAL STRESS ANALYSIS, annual meeting. Philadelphia. Sept. 21-23, 1954.

STEEL FOUNDERS' SOCIETY OF AMERICA, fall meeting. White Sulphur Springs, W. Va. Sept. 27-28, 1954.

ASSOCIATION OF IRON AND STEEL ENGINEERS, Iron and Steel Exposition and annual convention. Cleveland. Sept. 28-Oct. 1, 1954.

PORCELAIN ENAMEL INSTITUTE, annual meeting. White Sulphur Springs, W. Va. Sept. 29-Oct. 1, 1954.

STANDARDS ENGINEERS SOCIETY, annual meeting. Atlantic City. Oct. 1-2, 1954.

ELECTROCHEMICAL SOCIETY, fall meeting. Boston. Oct. 3-7, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, national aeronautics meeting, aircraft production forum and aircraft engineering display. Los Angeles. Oct. 5-9, 1954.

NATIONAL FOUNDRY ASSOCIATION, annual meeting. Chicago. Oct. 6-8, 1954.

AMERICAN GAS ASSOCIATION, annual convention. Atlantic City. Oct. 11-14, 1954.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, fall meeting. Chicago. Oct. 11-15, 1954.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS, south central regional meeting. Dallas. Oct. 12-15, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, national transportation meeting. Boston. Oct. 18-20, 1954.

AMERICAN SOCIETY FOR QUALITY CONTROL, New England conference. Albany. Oct. 21-23, 1954.

SOCIETY OF AUTOMOTIVE ENGINEERS, national diesel engine meeting. Cleveland. Oct. 26-27, 1954.

AMERICAN SOCIETY OF BODY ENGINEERS, annual technical convention. Detroit. Oct. 27-29, 1954.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS-AIME, joint fuels conference. Pittsburgh. Oct. 28-29, 1954.

AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS, Institute of Metals Div., fall meeting. Chicago. Nov. 1-3, 1954.

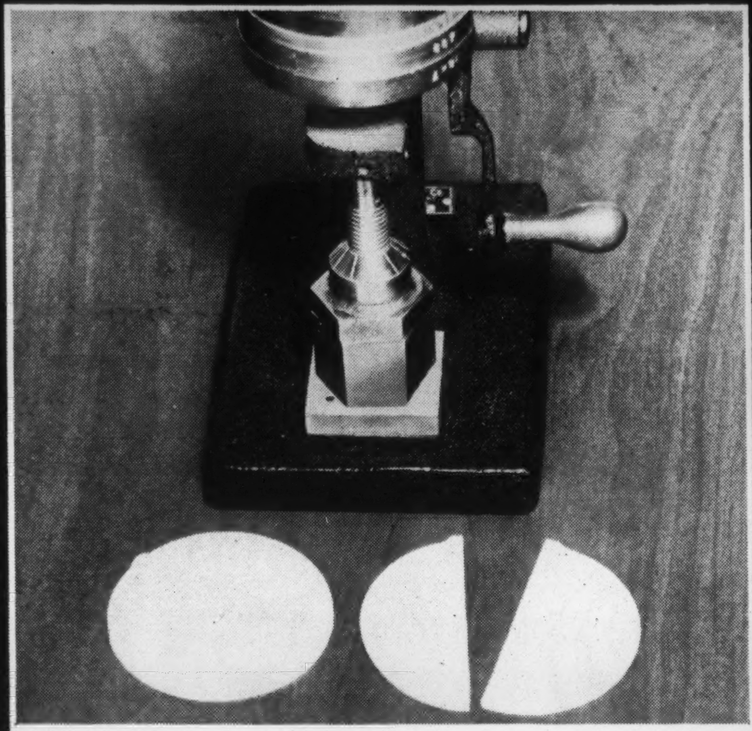
AMERICAN SOCIETY FOR METALS, national metal congress and exposition. Chicago. Nov. 1-5, 1954.

AMERICAN WELDING SOCIETY, fall meeting. Chicago. Nov. 1-5, 1954.

SOCIETY FOR NONDESTRUCTIVE TESTING, national convention. Chicago. Nov. 1-5, 1954.

Basic Materials Conference and Exposition. Philadelphia. June 12-16, 1955.

Tests show... Far greater toughness, superior flex strength...with HI-TEST 88 LUSTREX Styrene Plastic

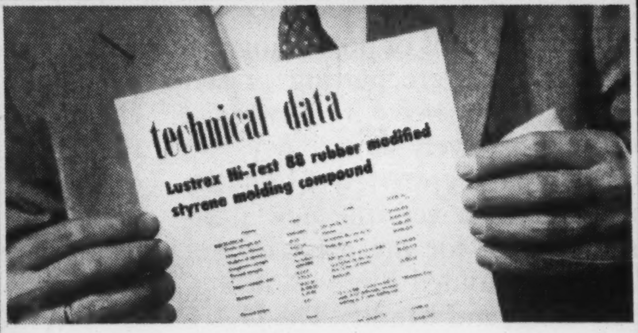


Compared to general purpose styrene—Lustrex Hi-Test 88 possesses up to 500% higher impact resistance, as indicated in this needle penetration test. Weighted needle of Toughness Tester is tripped to fall on test samples... *shatters* disc made of general purpose styrene (right), only *punctures* disc (left) of Lustrex Hi-Test 88.

Compared to other high impact styrenes—Lustrex Hi-Test 88 has better resistance to flexural fatigue (see demonstration above), finer surface gloss, and improved flow characteristics. It varies less in internal stress where there are adjacent thick and thin sections. Suitable for jobs involving lacquering.

Now you can provide *your* product with a real competitive advantage... with a stronger, tougher, more durable material: Monsanto's Lustrex Hi-Test 88 styrene plastic. *Five times tougher* than general purpose styrene, with superior resistance to strain and greater hardness, Lustrex Hi-Test 88 also possesses good appearance—high surface gloss and good color stability—plus excellent moldability.

For immediate information on how Lustrex Hi-Test 88 can help you improve the quality and sales power of your product, just use the coupon below.



technical data

Lustrex Hi-Test 88 rubber modified styrene molding compound

For your Materials Data Book—Basic engineering data you'll want for your permanent file on materials. Includes physical properties and performance characteristics, plus pertinent test information. Mail the coupon today for this valuable reference material.

MONSANTO

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MONSANTO CHEMICAL COMPANY, Plastics Division, Room 2209, Springfield 2, Mass.

Please send me a copy of your booklet, "Design for Sales," and technical data sheet on Lustrex Hi-Test 88 styrene plastic.

Name & Title __________

Company __________

Address __________

City, Zone, State __________

For more information, turn to Reader Service Card, Circle No. 496

WILL YOU BE FIRST

to make another profitable new use of

DURCZ PHENOLICS?

(A RECENT EXAMPLE)

A new competitive edge in your business, a wider market for your product, may well be awaiting an original use of Durez phenolics. As molding compounds or processing resins, these plastics are putting greater sales appeal into new or redesigned products almost every day.

This is what happened when the manufacturer of a versatile new portable sump pump for the mass market decided on a molded motor housing, pump housing, and handle. The Durez material helps to hold the pump weight down to less than five pounds. It resists the attack of moisture and electrolytic action, and withstands rugged handling. It also has the attractive glossy natural finish so familiar in radio and TV housings and other household articles molded of Durez.

Almost unbreakable, highly resistant to heat, impact, electrical current, chemicals, and moisture, Durez materials can help you turn the challenge of these changing times to profit. Experienced molders in your area are ready to serve you. We will gladly cooperate with our long experience as phenolics specialists . . . Write Durez Plastics & Chemicals, Inc., 1409 Walck Road, N. Tonawanda, N. Y.

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MOLDING COMPOUNDS

Structural, electrical, and chemical properties in many combinations.

RESINS FOR INDUSTRY

Bonding, casting, coating, laminating, impregnating, and shell molding.

PHENOLIC PLASTICS for the new Competitive Era

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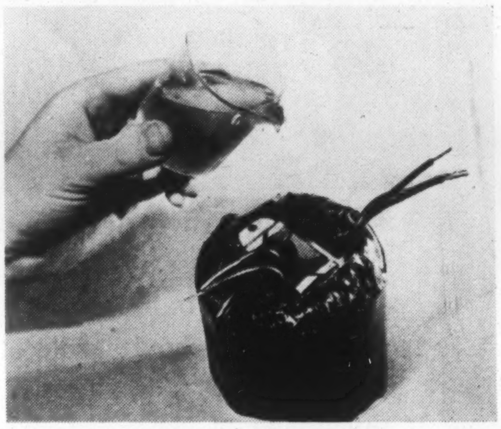
News Digest

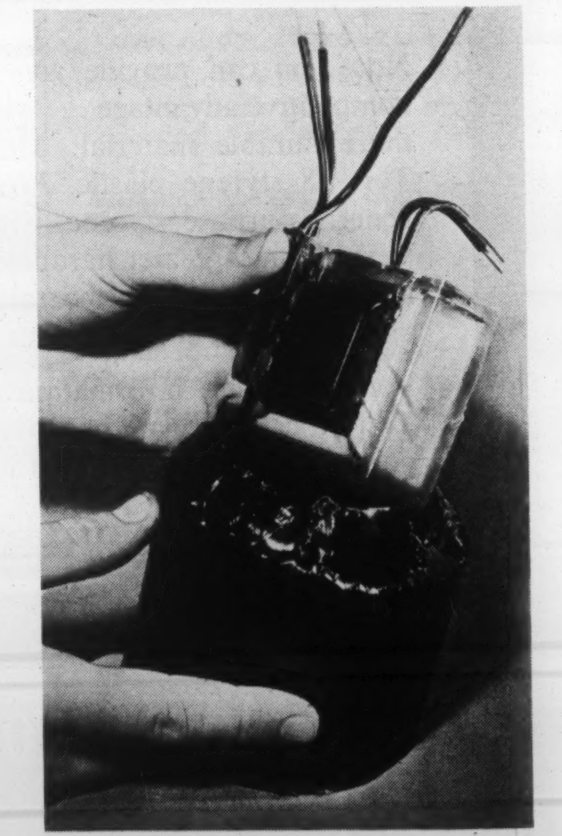
Plastisol Molds . . .

continued from page 13

flexible-mold method quickly accommodates to frequent design changes, and the technique is particularly economical for use with prototype, experimental, and contract models of equipment. Potting with flexible molds is accomplished in the same two steps used in casting. However, a master model of the potted assembly is necessary to shape the cavity in the mold around the electrical or electronic assembly. The low shrinkage of epoxy during cure insures a minimum of strain on the part. Assemblies and sub-assemblies such as rectifiers, transformers, antenna masts, deflection yokes and resistors have been potted by this method.

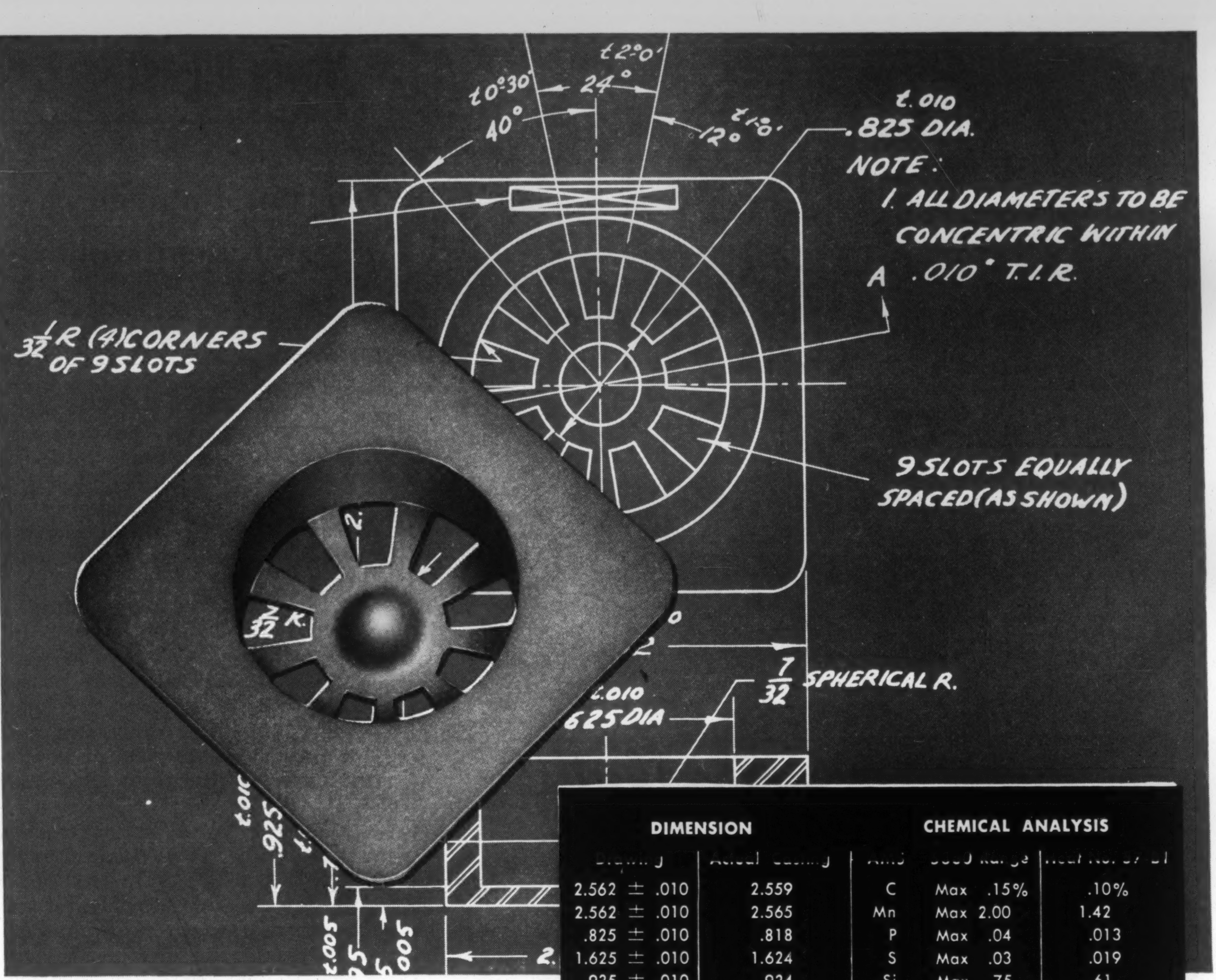


Epoxy resin is poured into cavities surrounding transformer in flexible mold.



Imbedded assembly is popped out of flexible potting mold.

(More News on page 226)


±2°0'
±0°30'
24°
40°
±1°0'
12°
±.010
.825 DIA.
NOTE:
1. ALL DIAMETERS TO BE CONCENTRIC WITHIN .010" T.I.R.
A
1/32 R (4) CORNERS OF 9 SLOTS
9 SLOTS EQUALLY SPACED (AS SHOWN)
1/32 R.
7/32 SPHERICAL R.
±.010
.625 DIA
±.010
.925
±.005

DIMENSION		CHEMICAL ANALYSIS		
Drawing	Actual Casting	AMS	Range	Heat No.
2.562 ± .010	2.559	C	Max .15%	.10%
2.562 ± .010	2.565	Mn	Max 2.00	1.42
.825 ± .010	.818	P	Max .04	.013
1.625 ± .010	1.624	S	Max .03	.019
.925 ± .010	.924	Si	Max .75	.61
.700 ± .010	.698	Ni	12.00-14.00	13.00
.105 ± .005	.109	Cr	16.00-18.00	17.70
2.050 ± .010	2.058	Cu	Max .50	.07
.295 ± .005	.293	Mo	1.50-2.25	1.96

Rely on

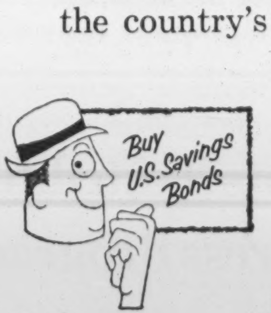
Crucible ACCUMET investment castings

for dimensional and metallurgical accuracy . . .

This intricately shaped aircraft instrument part had to be held to rigid specifications both in size and in chemical analysis of the steel.

That's why Crucible ACCUMET® precision castings were used. For Crucible's *lost wax* method of casting, and its long experience as the country's leading producer of fine special purpose steels, combine to bring you accurate castings of the highest quality. But the two tables shown below actually tell the story better than words can. They show how closely ACCUMET castings are held to original specifications.

The next time you have a job where quality and close tolerances are needed, be sure to investigate the advantages of ACCUMET precision castings – *call Crucible.*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first name in special purpose steels

54 *years of* *Fine* *steelmaking*

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CRUCIBLE STEEL COMPANY OF AMERICA, GENERAL SALES OFFICES, OLIVER BUILDING, PITTSBURGH, PA.

REX HIGH SPEED • TOOL • REZISTAL STAINLESS • ALLOY • MAX-EL • SPECIAL PURPOSE STEELS

Canadian Distributor — Railway & Power Engineering Corp., Ltd.

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DURASPUN
SCREW CONVEYOR

Durable
. . . because it's properly alloyed

Strong
. . . because it's centrifugally cast

Centrifugal Castings can be more than conventional piping. Almost any roughly cylindrical shape can be cast centrifugally provided a straight hole through the center is allowable. In the casting machine the molten metal is thrown outward, making it impractical to cast solid.

This Duraspun Screw Conveyor is typical of the unusual castings produced in our centrifugal casting department. On straight piping, our machines are capable of turning out pipes ranging in 2½" to 31" OD and, according to diameter, up to 15' long.

If you are interested in superior castings — more uniform, denser and pocket-free castings — order centrifugal castings. Write us about your requirements and we'll recommend the proper alloying elements to meet your corrosive, high temperature, abrasive conditions.

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Detroit Office 23906 Woodward Avenue • Pleasant Ridge, Mich
Atlanta J M TULL Metal & Supply Co
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News Digest

BDSA Publishing New Patent Guide

The first of a series of seven volumes on government-owned inventions is now available from the Office of Technical Services, United States Department of Commerce. The first volume, which covers the field of instrumentation, marks the beginning of a series intended to give further encouragement to American industry to take advantage of government sponsored technical research.

Dr. A. M. Palmer, Chairman of the Government Patents Board, pointed out that government-owned inventions are available to industry on a royalty-free basis. The seven volumes of patent listings will make it a simple matter to locate government-owned patents in almost any field.

The first volume, *Instrumentation,* contains 775 listings classified under eight sub-groups. The six books which will follow later this year are: *Chemical Products and Processes* (1349 abstracted inventions), *Food Products and Processes* (265 abstracts), *Metal Products and Processes, Machinery and Transportation Equipment* (658 abstracts), *Electrical Apparatus* (1920 abstracts), *Ceramic, Paper, Rubber, Textile, Wood and other Products and Processes* (308 abstracts), and *Ordnance* (647 abstracts).

Each volume lists Field Offices of the Dept. of Commerce and Small Business Administration which may be consulted concerning the availability and use of the listed government patents.

The book, *Instrumentation,* may be purchased from the Office of Technical Services for $2.00. The order number of the book is 111464, and must accompany any request for the volume.

Big Ingots Tested for Heavy Press Program

The 35,000-ton and 50,000-ton forging presses now under construction for the Air Force Heavy Press program will get ingots commensurate with their size. Completion of forging tests on 5000-lb 24S alumi-

CHROMALOX

Electric Heaters

STRIP HEATERS

In straight lengths, formed or "finned" for conduction or convection heating. Industry's rugged and versatile heat source for many uses.

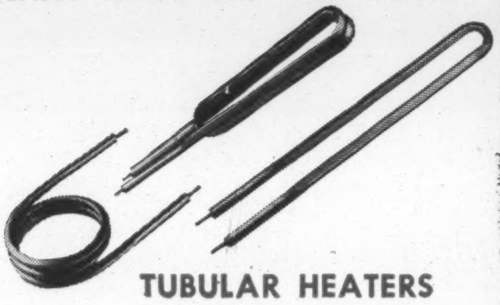
CARTRIDGE HEATERS

Installed in an instant in drilled holes for heating dies, platens, moving parts, rolls, molds, etc. Types available for immersion heating in liquids.

SHEATHED IN METAL FOR STRENGTH—INSULATED ELECTRICALLY FOR SAFETY

IMMERSION HEATERS

For heating water, oil and other liquids. Wide variety of types and sizes for portable or permanent installations, with or without built-in thermostats.



TUBULAR HEATERS

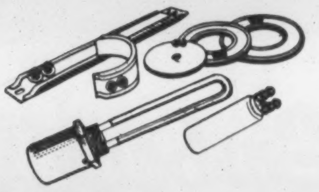
Straight lengths or tailored to any desired shape. For heating liquids, solids or gases by conduction, convection or radiation. Many sheath types.

Your LOW COST SOLUTION to processing heat problems!

Chromalox Electric Heaters give you quick, on-the-spot heat for a wide range of uses. They provide dependable, efficient, economical around-the-clock service in applications requiring continuous, accurately controlled temperatures. Thousands of plants in all industries have found Chromalox Heaters the low cost solution for heating liquids and gases; for heating dies, platens, moving parts; for superheating steam and pre-heating oil; in fact—for almost every industrial application using heat.

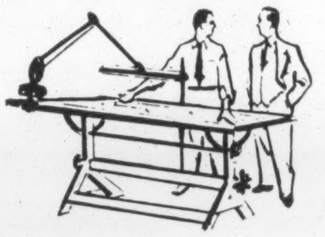
CHROMALOX

OFFERS YOU THE MOST IN ELECTRIC HEAT



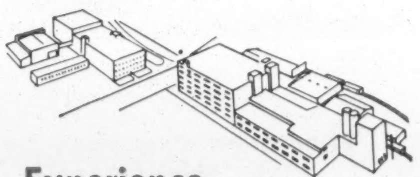
Selection . . .

Over 15,000 types, sizes and ratings fill most applications needing heat up to 1100° F.



Engineering . . .

Research, development and technical personnel provide a vast reservoir of industrial heating know-how.



Experience . . .

World's largest manufacturer of electric heating units exclusively. 35 years of designing and manufacturing skills.

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Over 130 field engineers in 36 key cities give on-the-job assistance and counsel.

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CHROMALOX
Electric Heating Units

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Catalog 50 is a storehouse of valuable information and data on many of the 15,000 Chromalox Electric Heating Units. Write today for your copy.

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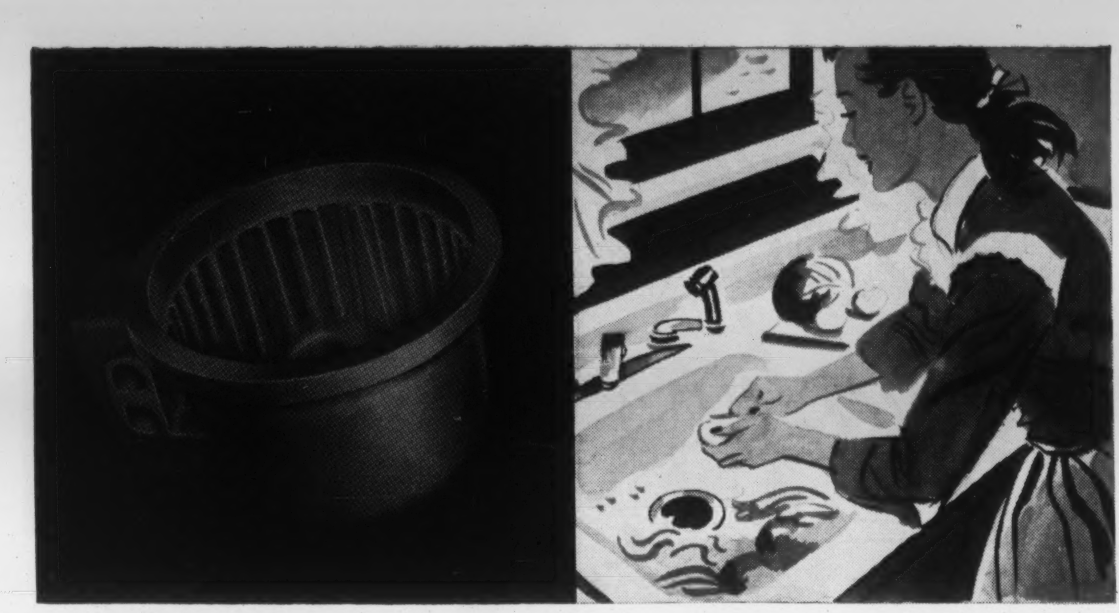
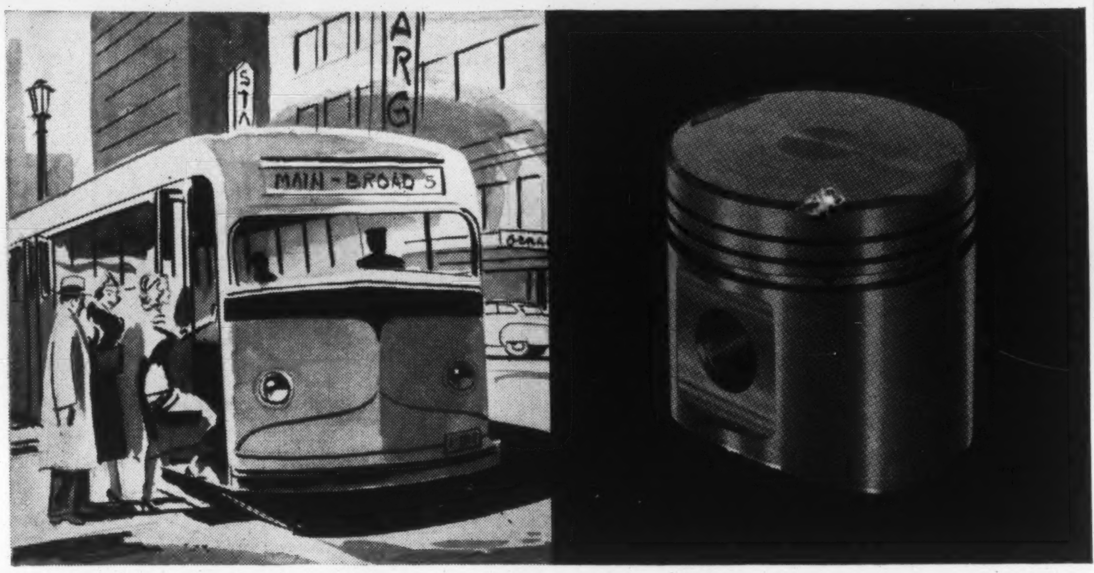


Garbage Disposers and Buses



Thompson Precision-Engineers Light Metal Castings for All Industry

A HOUSEWIFE using her garbage disposer unit and a bus driver threading his way through traffic have one thing in common —both count on Thompson. The garbage disposer unit and the bus are each improved by precision-engineered castings made by Thompson's versatile Light Metals Division.

The housewife's garbage disposer uses several parts manufactured by Thompson, including the housing—the bus uses several precision-engineered parts, including pistons.

Garbage disposer housings and bus engine pistons are but two of the many light, strong, durable castings designed, developed and manufactured by Thompson for a long list of diversified customer uses. Today Thompson is producing light metal castings for such products as washing machines and jet planes, outboard motors and tractors, automobiles and industrial engines; ice scoops and aircraft engines.

Behind this ability to aid all forms of industry are over 50 years experience in research and manufacture of precision metal parts. Regardless of your product, if you use castings, Thompson's creative engineers will gladly show you where and how you can simplify your operations and save on costs with Thompson Light Metals Castings.

For a detailed description of the Thompson Light Metals facilities which are available to you, send for your free copy of "Creative Castings." Just write to Dept. MMM, Light Metals Division, Thompson Products, Inc., 2269 Ashland Road, Cleveland 3, Ohio.

You can count on

Thompson Products

LIGHT METALS DIVISION
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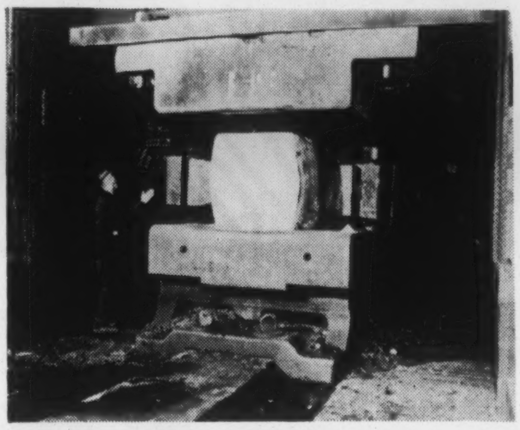
News Digest



5000-lb ingot is forged into 30-in. cube on 7000-ton press.

num alloy ingots indicate that the big ingots are sound and are of a quality equal or superior to those of more conventional weights.

The 5000-lb ingots were cast by a modified direct chill casting process at the Department of Metallurgical Research of Kaiser Aluminum and Chemical Corporation. The forging test consisted of shaping seven 24S, 32 in. dia 70 in. long as-cast ingots into plate blooms 13 by 24 by 85 in. A total of 13 forging steps formed the blooms for rolling into heavy plate.

To prepare the ingots for forging, they were heated to 700 F over a period of 30 hr and soaked at temperature for 12 hr. The tests utilized a 7000-ton hydraulic steel forging press at U. S. Steel's Homestead works.

The first forging operation pressed the ingots into barrel shaped pieces 36 in. high. In three more steps each piece was cross worked at right angles, resulting in a 30 in. cube. At this point, a die change was necessary due to the small size of the press. Total press time per ingot was about 90 min, with the die change at the half way point.

Large aluminum ingots are difficult to produce due to segregation and shrinkage problems. Observers of the test forging of the 5000-lb ingots concluded that the success of the test was due to a large extent to the soundness and good metallurgical structure of the material. The success of the first attempt to forge aluminum ingots of this size marks an important step in making satisfactory materials available for the giant presses which the Air Force hopes to use to produce stronger and larger aluminum forgings for aircraft structural uses.

(More News on page 230)

Let's Get Together

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- Rubber and Fiberglas moldings
- Plastic and rubber extrusions
- Metal stampings
- Vibration and shock mounts

General's design and development engineers translate your problems into finished products in modern, completely equipped plants... the whole job—from the drawing board to the final shipment—is handled as a package assignment. This service includes tool and die-making facilities, self-designed molding and extruding machinery, and a full-scale quality control safeguard at every phase of manufacture.

Why not look into our successful record on motion control products, extrusions, moldings, stampings and special units? For further information fill out the coupon below.

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Would a superior coil spring solve your design problem?

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- ★ *High Conductivity*
- ★ *Uniformity*
- ★ *Reduced set and drift*
- ★ *Close tolerances*
- ★ *Long endurance life*
- ★ *Corrosion resistance*
- ★ *Stability at extreme temperatures*
- ★ *Reduced inspection and assembly costs*
- ★ *Reduced space requirements*

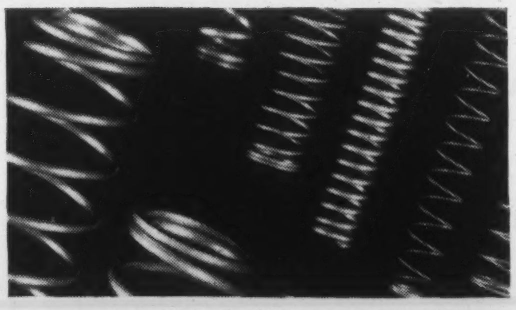
It is known that beryllium copper does have certain inherent advantages for some applications. But I-S exclusive heat-treating techniques in spring-forming have magnified and multiplied these advantages. From jet aircraft to refrigerators, billions of I-S BeCu springs have been used for their superior performance—and the resulting economies in cost and labor.

Call it difficult? Then call I-S . . .

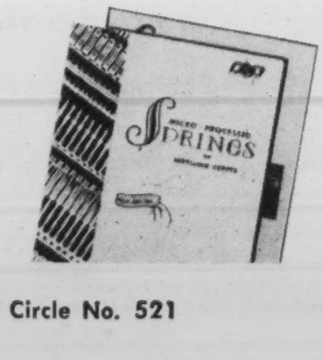
From design conference—to prototype—to finished production . . . I-S' exclusive facilities and the specialized ability of our engineering staff are available to help solve your challenging problems.

Like many other leading manufacturers, you will find that these I-S facilities can make significant improvements in your manufacturing processes, and in your product. And they most likely will save you money. One thing is certain . . . it costs nothing to compare.

But it may cost considerable, not to!



For more information on BeCu Springs, write today for your free copy of our newest catalog, No 8. For electronic components, ask for No. 8-A.



Instrument Specialties CO. Inc.
224-H BERGEN BOULEVARD, LITTLE FALLS, NEW JERSEY
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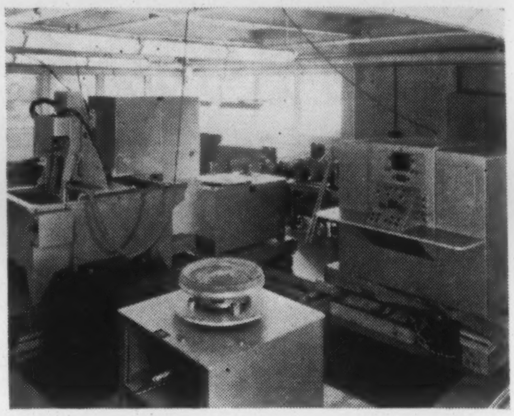


Reflectoscope set up for automatic production testing.

Ultrasonic System in Production Testing

An automatic ultrasonic testing system integrated into jet engine production lines is expected to result in great economics for the Allison Engine Division of General Motors. The new installation consists of a Sperry ultrasonic Reflectoscope controlled by digital automation equipment. Like other automation set-ups, this one too has a name—SIMAC—which is short for sonic inspection measurement and control. While the test equipment is primarily intended to inspect jet engine rotor forgings, the $300,000 system is not a single purpose machine; it can be programmed by means of punched tape to handle a variety of parts and shapes. In its initial installation, the equipment will probe forgings for defects before expensive machining begins.

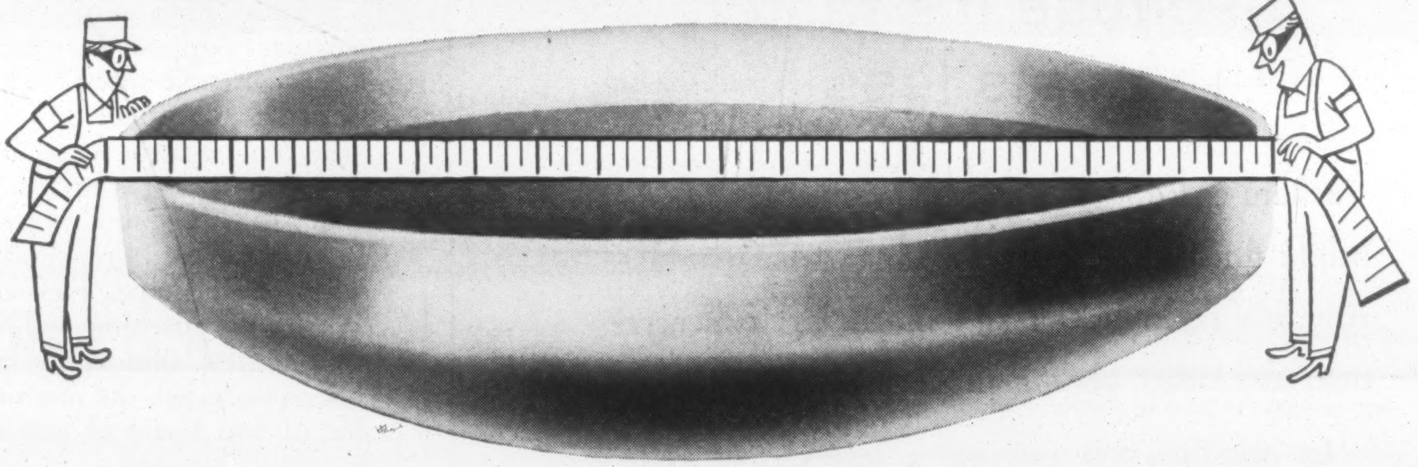
Parts under test are submerged in water on a circular turntable. Sequence of testing is programmed and results recorded on a polar graph. The scanning machine consists of a rectangular tank having a turntable in the bottom and horizontal ways at the top. A rigid carriage slides on the ways and is positioned horizontally by a lead screw. A smaller second carriage carrying the scanning head slides on vertical ways affixed to the horizontal unit.

By continuously rotating the turntable and varying the horizontal, vertical, and angular position of the scanning head, the specimen is completely scanned by ultrasonic beams from a quartz crystal transducer mounted in the scanning head. The transducer transmits short bursts of ultrasonic sound at 5,000,000 cps.

Parts are aligned on a jigging

CLAYMONT FLANGED AND DISHED HEADS

from 9 inches to 19 feet in diameter



Flanged and dished heads made by Claymont are available in sizes from as small as 9 inches to as large as 19 feet in overall diameter; and in gauges from 3/16-inch to 6 inches. They can be supplied in carbon steel, alloy steel or with stainless steel cladding.

All carbon and alloy steels are the product of our own open hearth furnaces—closely and completely controlled to meet customers' specifications.

We are also prepared to handle head-forming operations on both ferrous and non-ferrous metal supplied by the customer. To order, write or call Claymont Steel Products Department, Wickwire Spencer Steel Division, 813 West Street, Wilmington 99, Delaware.

Claymont Steel Products

CF&I

Products of Wickwire Spencer Steel Division • The Colorado Fuel and Iron Corporation

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Other Claymont Products . . . **Carbon and Alloy Steel Plates • Stainless-Clad Plates • Manhole Fittings and Covers • Large Diameter Welded Steel Pipe • Flame Cut Steel Plate Shapes**

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Best Way
to Plate It is
Vacuum Coating
because it's faster,
costs less

Vacuum coating gives plastics or metals a mirror-bright finish that's right for every decorative use. And it's faster, easier and much less expensive than any other plating process.

In minutes you can get a *truly bright* plate, with aluminum, copper, gold, silver, or almost any other metal. Materials costs are negligible: a pound of aluminum covers 25,000 square feet.

Cost of an NRC Vacuum Coater is low. Write now for a copy of the NRC Vacuum Coater bulletin.

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News Digest

plate, then transferred to the submerged turntable of the scanning machine. The water serves as an efficient conductor of ultrasonic waves between search unit and part undergoing inspection.

Scanning passes in controlled sequence probe the entire volume of the specimen. Unwanted discontinuities within the material reflect the ultrasonic sound, and the recording mechanism indicates the position and type of defect on the chart.

Control of the sequence of scanning is fully automatic. Each required motion of the scanning head—horizontal, vertical and angle of inclination—is provided by a servo-motor reacting to an array of holes punched in a paper tape. A scheme which provides 12 holes for each function of the scanning machine provides a possible 4096 "positions" for each servo-motor. In all, 60 holes are punched in the tape for each scanning pass. The servo-motors and control automatically go into action to "program" horizontal, vertical, and angular positions of the scanning head, turntable speed for rotating the specimen, ultrasonic power level, and four other control functions necessary to operation of the machine. Any number of required scan lines can be programmed by punching hole-lines on the tape. First commercial use of the machine will require 15 min to test thoroughly each piece, but, if required, the machine is capable of two hours of continuous and automatic testing.

A recorder makes a continuous plan view of the results of the ultrasonic test while the scanning procedure advances. The recorder consists of a rotating table holding a paper chart, 28 in. in diameter, and a fast-acting recording pen. The resulting permanent record shows all ultrasonic echo signals amplified from the search unit. Test results can be interpreted while in process and can be filed for reference.

All operations of the apparatus are vested in the electronic console. At this station an operator can control the machine either manually or switch to automatic testing. All ultrasonic echo signals are indicated on a cathode-ray tube to provide visual monitoring. The console incorporates a Sperry Reflectoscope as a basic part of the complete system.

(More News on page 234)

finished part cold-extruded in one piece

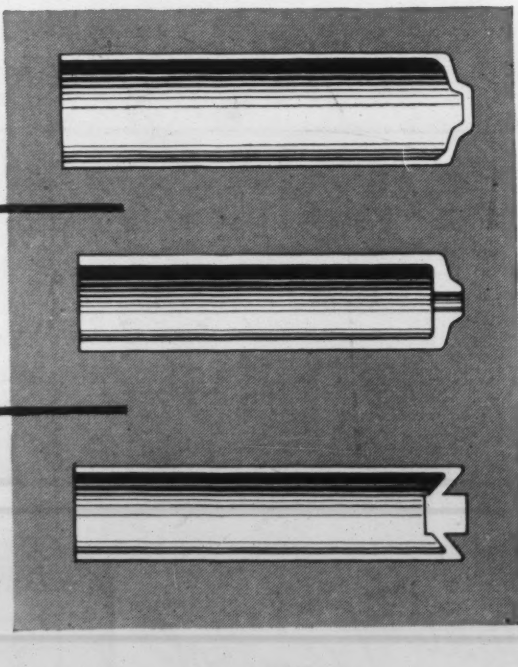
Diameter: 1⅜ inches
Tolerance: ±.001 inch
Surface: 60 microinches or better

Let Mullins Koldflo produce your ideal designs at *less cost!*

PRECISION steel parts like this can be *mass-produced* — at less cost — by the new Mullins *Koldflo** process. These extrusions are finished — no machining or fabricating required. Now, with fewer manufacturing limitations, you can design cylindrical parts the way you *want* them — without compromise. If you require precision parts, in high volume, call the nearest Mullins office today for engineering appraisal. Write for your copy of the new 16-page bulletin, *"How Would You Tool-up to Make an Egg?"*

*Trade Mark

Here is what designers say about Koldflo extrusions:



Pump manufacturer says:
"Surface finish and tolerance on our main pump body are critical. Your cylinders meet specifications at lower cost."

Auto manufacturer says:
"Our application involves high pressures. One-piece Koldflo extrusions provide assurance of required strength, at a saving."

Steel products manufacturer says:
"Surface finish, close tolerance and low cost all important. Your design meets our requirements."

Koldflo
DIVISION
MULLINS MANUFACTURING CORPORATION
Salem, Ohio

Phone — Salem 8771

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HOW you can meet close tolerances on parts like these!

1

Cut costs, speed inspection, with understage illumination

Bausch & Lomb BENCH COMPARATOR
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Quality Control INSTRUMENTS

News Digest

To Survey Plastics Used in Housing

A broad survey of the usefulness of plastics as a material for housing will be the subject of a one-year research program now in organization stages at the Massachusetts Institute of Technology.

Dean Pietro Belluschi of M.I.T.'s School of Architecture and Planning announced last month that a grant of $10,000 from Monsanto Chemical Company will support the one-year project. A committee of five members of the M.I.T. faculty is supervising the study.

R. K. Mueller, Monsanto vice president and general manager of the firm's Plastics Division, said the grant was made to expand the industry's knowledge "of the proper and sound use of plastics in home design and to avoid misapplications. The project should uncover new concepts of plastics as a material for housing design, as well as beneficial guides for the plastics industry in developing appropriate applications for its versatile products in this field."

Dean Belluschi also pointed out that the survey would emphasize existing applications in which plastics have proved successful and new applications which are definitely sound. "We expect," he continued, "that this study will yield illustrative material in the form of creative suggestions for the use of manufacturers, fabricators, and designers."

The project, Dean Belluschi said, will study plastics of all sorts as well as certain other building materials. The research will proceed on the basis of the various functional problems of housing constructions and decoration in which plastics may play a part—foundations, floors, walls, partitions, roofs, windows, doors, storage closets and cabinets, mechanical equipment and services, furnishings, and decoration. In each case the purpose will be to consider how new plastics may be more effectively used, in current practice as well as in long-range trends.

The new research project will be guided by an advisory committee of which Professor Burnham Kelly of the M.I.T. School of Architecture and Planning is chairman.

(More News on page 236)

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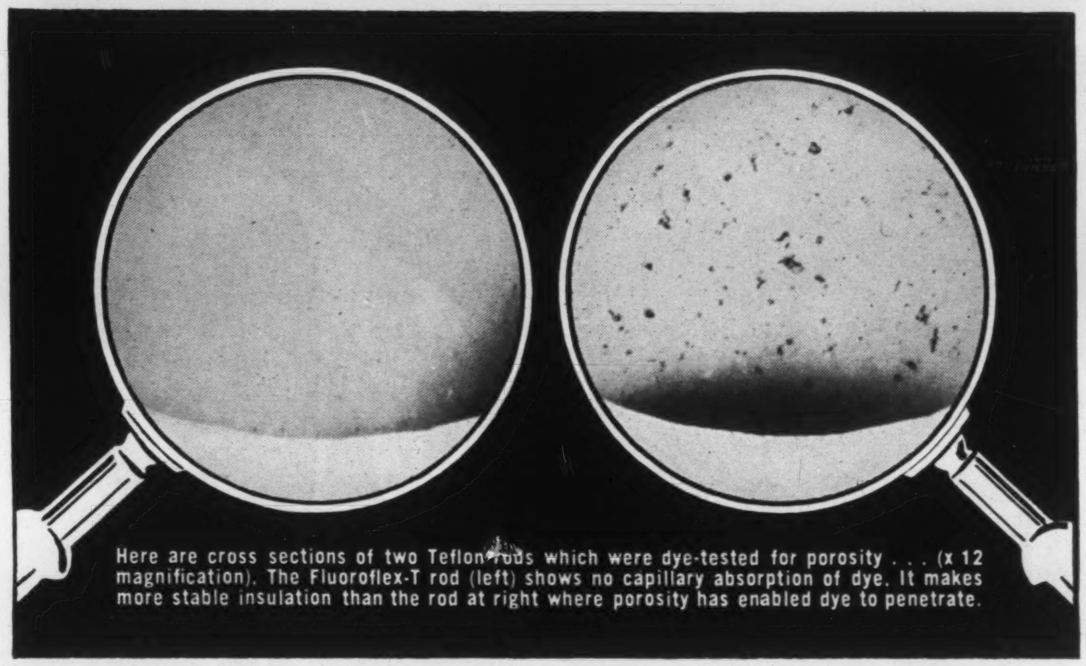
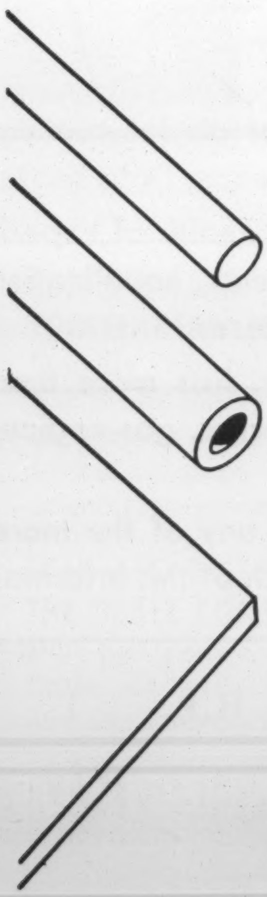
Are you getting TEFLON* with no porosity



Here are cross sections of two Teflon rods which were dye-tested for porosity . . . (x 12 magnification). The Fluoroflex-T rod (left) shows no capillary absorption of dye. It makes more stable insulation than the rod at right where porosity has enabled dye to penetrate.

Non-porous FLUOROFLEX®-T *rod, tube, sheet assure optimum electrical stability in parts*



At its optimum electrical values, Teflon is virtually the perfect dielectric material for UHF use. If, during extrusion or molding, however, a high degree of porosity results, dielectric strength, power factor and dielectric constant are bound to be affected. That's because *porous* insulation means *absorbent* insulators.

As the above photographs show, Fluoroflex-T is *non-porous*. This is achieved in two ways. (1) By processing on equipment especially designed to compact Teflon powder to the critical density. (2) By not bleaching out Teflon's natural spotting at the expense of optimum density.

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News Digest

Aluminum Sheathing by Direct Extrusion

Production facilities for direct-extruded aluminum-sheathed cables will be set up by General Cable Corporation in one of its East Coast plants, company officials have revealed. The firm has completed arrangements with a West German press manufacturer to purchase an aluminum extruding press of the type now in commercial use in Europe for extruding aluminum over insulated cable cores.

Several thousand miles of aluminum sheathed cable are now in use in Europe, and it is considered an established product well out of the experimental stage.

In the U. S., aluminum has been recognized for years as a promising material for cable sheath because of its light weight, corrosion resistance and high mechanical strength. However, the complicating factors of high temperature and pressure in the extrusion process has hindered development of direct extrusion methods for covering cables. Various expedients have been tried, such as seam welding an aluminum strip around a cable, threading the cable through an oversize tube and subsequently drawing the tube down tight over the cable. Several hundred miles of aluminum cable made by these processes has been used in the U. S. and has given gratifying results.

General Cable officials predict that the direct extruded aluminum cable will result in new designs of very high voltage overhead cables, lighter communication cables for aerial installations, improved coaxial cables, and quite possibly longer spans, which would lower construction costs for cross country installations.

Friction Materials Laboratory Opened

A laboratory devoted exclusively to research, development and testing of friction materials has been opened by the Johns-Manville Corporation in Manville, New Jersey. The new laboratory, the largest of its type, is equipped to test and produce in pilot plant quantity a wide range of fric-

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AS COMPARED with other methods, this roll-and-weld process is able to produce preshaped, accurately dimensioned blanks that often do away with all rough machining and the expense of much excess metal. These blanks are stronger, too, because they have continuous grain flow throughout. Since they're practically free of subsurface defects, rejection of nearly completed parts is virtually eliminated.

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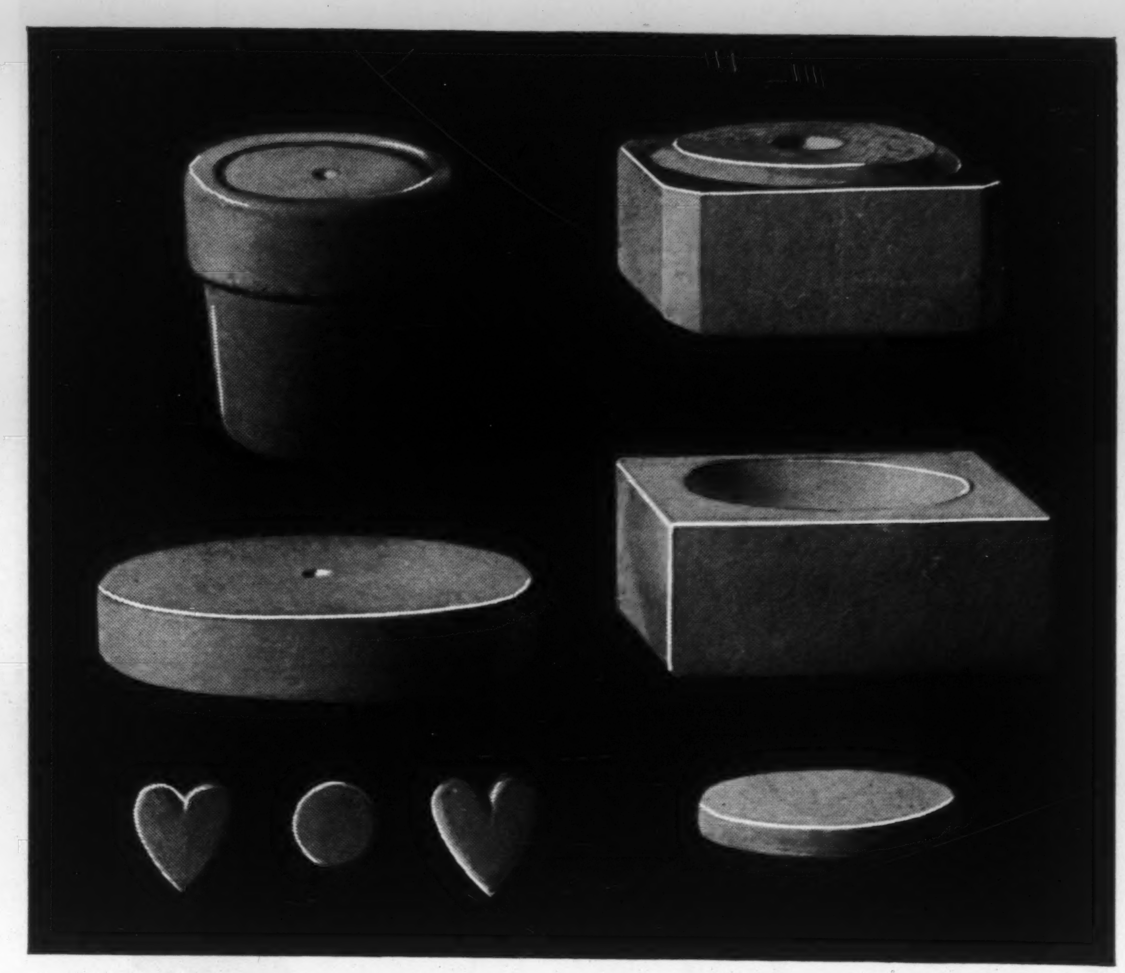

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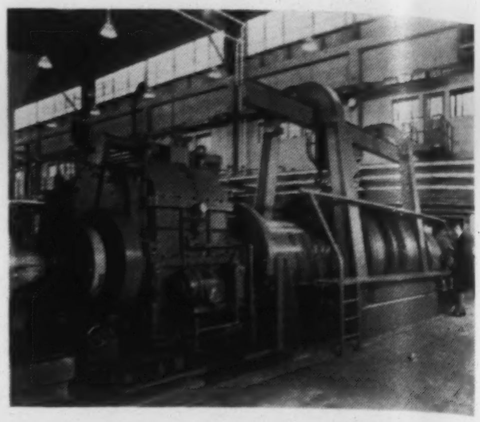
News Digest



World's largest inertia dynamometer, recently installed in Johns-Manville Research Center, can duplicate the most extreme braking conditions of transportation and industrial equipment. The 200-ton machine develops up to 100,000 ft lb of braking torque—more than twice as much as is encountered in the most severe braking requirement in actual use today, the 42,000 ft lb of the Globemaster transport.

tion materials used in industry as brake linings and clutch facings.

Dominant among the testing equipment installed in the new lab is a 200-ton inertia type dynamometer capable of testing a diversity of brake linings and friction materials under conditions exceeding any likely to be encountered in actual use, now or in the near future. The machine operates over a wide range of speeds and powers, and can reproduce the conditions under which brake linings operate in high speed aircraft or low speed heavy torque earth moving machinery.

The dynamometer is driven by a 500-hp variable speed electric motor and contains a variable weight flywheel which can give inertia loadings from 150-slug ft sq to 6750-slug ft sq in increments of 50 slug ft sq. A gear reduction unit provides two ranges of speeds—0 to 300 rpm for low speed high torque test and 0 to 1500 for higher speed applications. Maximum brake torque is 100,000 ft lb and maximum kinetic energy of the unit is 51 million ft lb. The machine is electronically controlled and records test information on a four channel oscillograph and an oscillograph movie camera combination which is arranged to read high speed temperature variations.

(More News on page 241)

For more information, Circle No. 524 ➤

Electroplates Nickel On Raw Aluminum

A new process for nickel plating aluminum has eliminated use of an intermediate bonding material. The technique is reported to materially strengthen the aluminum in addition to providing an erosion resistant surface.

Developed by Bart Laboratories of Belleville, New Jersey, the electroplating process results in deposits of nickel directly on raw or anodized aluminum which provide a surface that is resistant to erosion, pitting, gouging and corrosion. When applied in a thin layer to both surfaces of aluminum sheet, the coating strengthens the aluminum without a significant increase in weight. The process provides a uniform protective coating of nickel on both interior and exterior surfaces of intricate shapes, such as machined parts or castings.

S. G. Bart, President of the Laboratories, claims the new electroplating process solves one of the major problems in coating aluminum with nickel by eliminating intermediate materials such as copper or adhesive cements. The nickel aluminum bond has been considered impossible for practical purposes.

The nickel aluminum bond is strong, is not subject to separation at high temperatures, and coated stock can be bent, sheared or drawn. The coating is ductile and pore free. Wide thickness latitudes are possible, as well as variation in the characteristics of the deposited nickel. Hardness is controllable over a wide range, from 150 to 550 Vickers. If needed, the nickel can be deposited in layers of varying hardness, with a soft layer against the aluminum for resiliency and a hard outer coating for erosion resistance.

The new process is expected to increase the service life of parts subject to extreme corrosion and erosion, such as propeller blades of water-based aircraft.

Pilot Metal Plant Planned

Westinghouse Electric Corp. broke ground recently for construction of its

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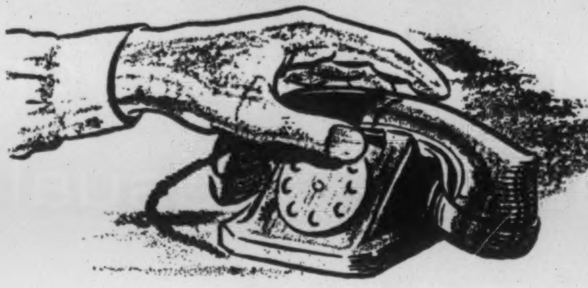

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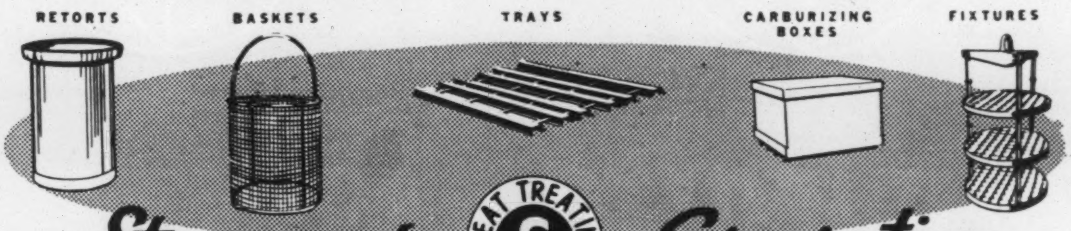

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One S&W "A" Type Furnace now used to bright copper braze stainless steels has 8" clearance above belt — contradicting usual belief that working height of constantly opened furnace doors must be less than 3" to get bright work. Ask about other ingenious installations.

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Complete Line of Electric and Fuel-Fired Furnaces To Meet Every Industrial Need
Atmosphere Generators • Ammonia Dissociators • Gas Conditioning Equipment

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News Digest

new multi-million-dollar metals plant at Blairsville, Pa., it was announced by Warren M. Trigg, plant manager. The main purpose of the new plant will be to bridge the gap between research and the commercial application of metals in the electrical industry.

This plant will provide equipment for the basic metal working processes of melting, forging, hot-rolling, cold-rolling, conditioning, pickling and heat-treating. In addition, facilities for the newer foundry techniques of investment casting and shell-mold casting will be installed. Also provided will be equipment for limited manufacture of powder metal parts.

Mr. Trigg pointed out that metallurgical advances have made possible much of the recent progress in the fields of jet propulsion, atomic power, and electric power generation. "The future requirements for improved metals," he said, "have pointed to the necessity for increased efforts in this rapidly advancing field."

Twenty years ago steam turbines were being built to operate with steam temperatures of about 800 F and pressures of about 1200 lb. New units now are being designed for 1100 F and up to 4000 lb pressure. Metals had to be developed to withstand these higher temperatures and pressures before the generator advances were possible.

"Evidence of what has been achieved is apparent," Mr. Trigg said, "when you look at the great increases in size and speeds of generators. The largest 3600 revolutions per minute machine 20 years ago was less than 25,000 kw in capacity. Today Westinghouse is working on a generator of 260,000 kw capacity. That's progress."

In the field of military equipment jet aircraft engines are continually getting bigger and hotter. The science of metallurgy has provided a complete array of new alloys and metals that will withstand the severe conditions imposed by these new designs. New techniques of melting, casting, welding and powder pressing have made available new means for shaping parts that have solved many fabricating problems.

The rapid increase in electric power consumption per capita in the United States, plus the rapid population growth, forecasts a shortage of energy resurces in the not too distant

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One Company now finds it takes only a few seconds to find wanted facts about *any one of its 5000 employees!* What's more all pertinent information is visibly signalled so that even such things as in-grade pay increases are handled automatically by clerks . . . thus relieving plant supervisors of the necessity of keeping and watching records . . . and assuring greater accuracy with much less clerical effort.

Previously, the personnel record for each employee of this company (Union Bag & Paper Corp.) consisted of an ordinary file folder. Reference required its papers to be leafed through until the proper sheet was found, leaving its contents disarranged. All this was changed so easily by adopting sturdy Classifile Personnel Folders fitted with space-saving patented Kompakt fasteners, which permit segregation of papers in convenient classifications and lock every record securely in place.

Information Visibly Signalled. Even more important, all pertinent information of personnel records at Union Bag, is easily and quickly posted to the Kardex visibly signalled record, before it goes to the folder. Hence, the Kardex at all times reflects, at a glance, a complete picture of what is in the file, and makes it available for instantaneous reference and use.

All personnel folders at Union Bag are housed in Remington Rand *certified* insulated Safe-Files*. . . and all Kardex are *certified* insulated Safe-Kardex . . . assuring protection from the ravages of fire.

Get the full story, "How Remington Rand Systems Simplified Personnel Records at the Union Bag & Paper Corp. of Savannah, Ga." Circle CR906.

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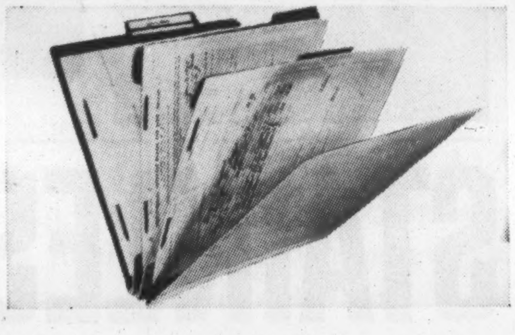

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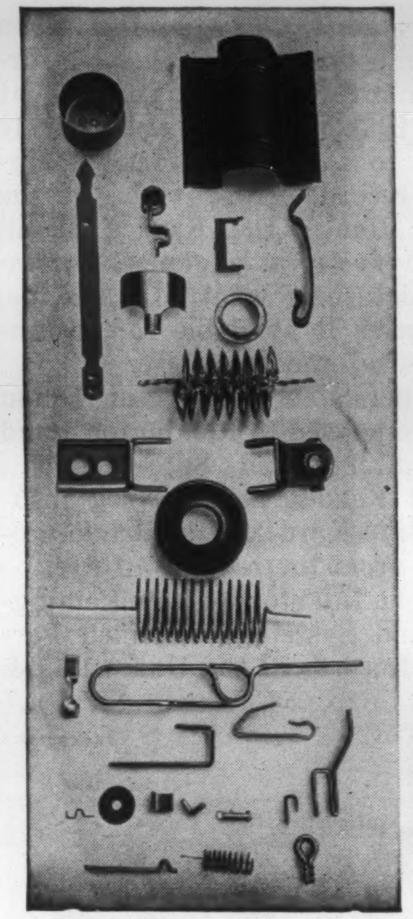

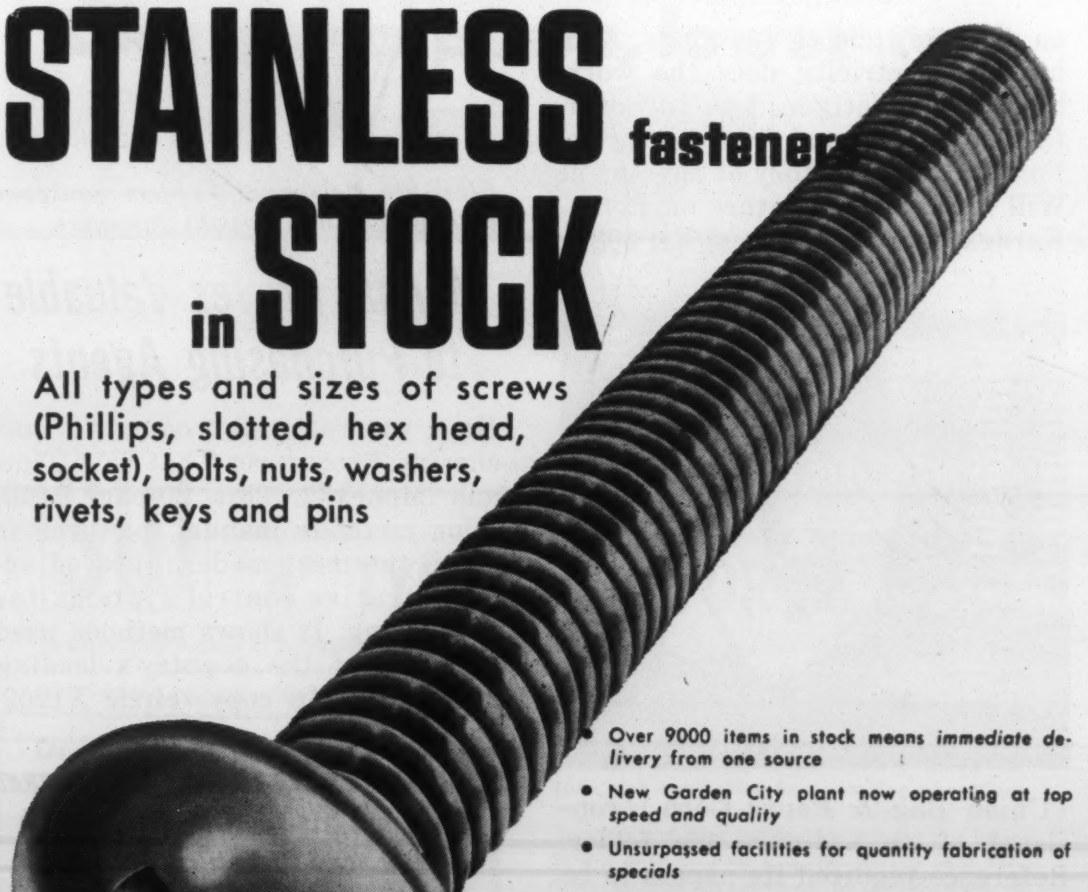

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future. This means that it will be necessary to produce power from nuclear material—atomic power.

"The design of the atomic engine which Westinghouse built for the submarine Nautilus was made possible only by the solution of many metallurgical problems," said Trigg. "The future large scale generation of power from nuclear energy hinges on the solution of additional metallurgical problems."

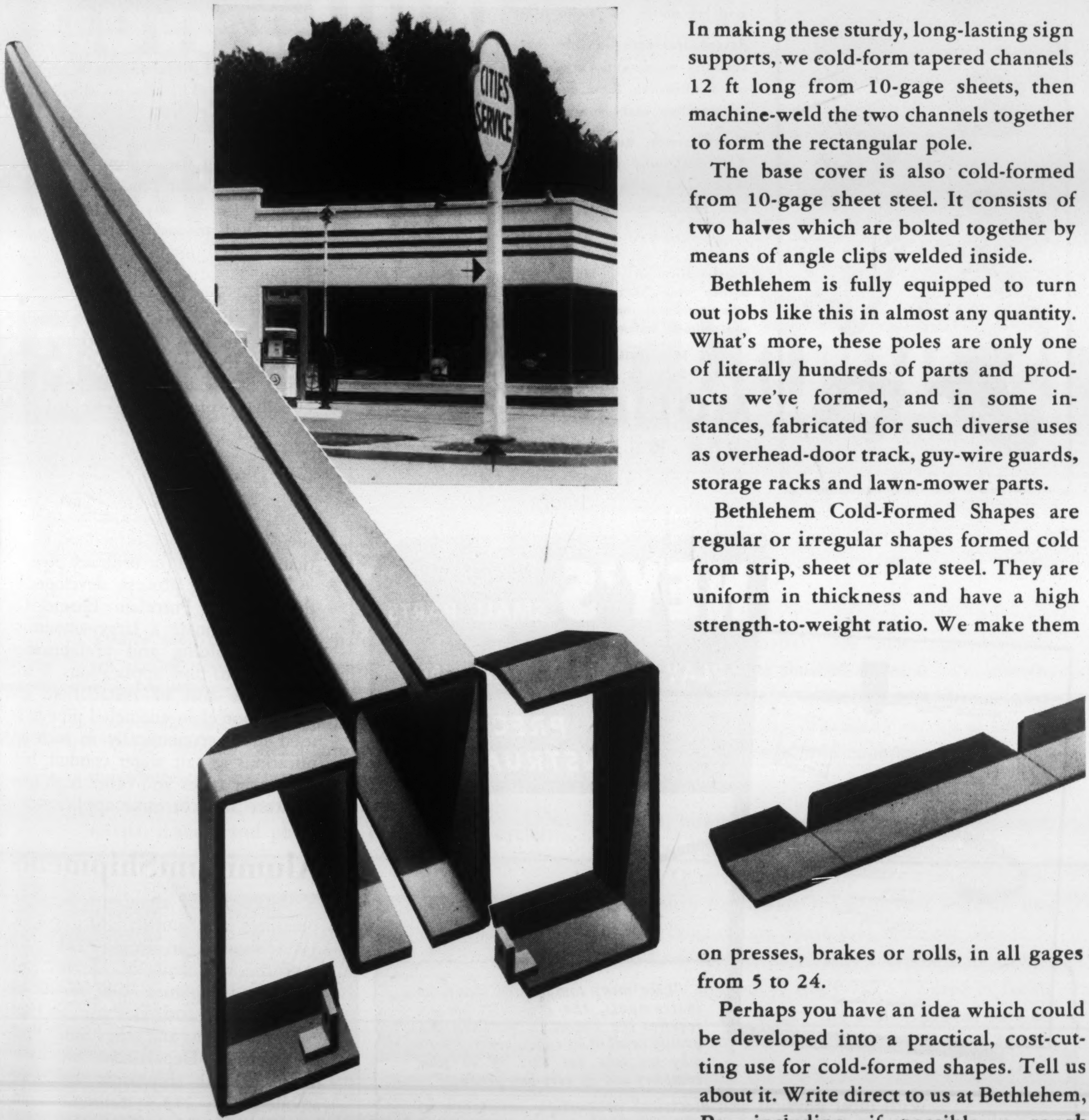
Melamine Decorating Process Available

A process is now available for bonding decorations in melamine plastic. The Einson Freeman Company of Long Island City, New York, a lithographic firm, obtained a licensing agreement in 1953 on European developments, and has now perfected the process with the cooperation of Monsanto Chemical Corp. The technique produces a sealed-in decorative effect on conventional melamine plastic products such as dishware and jewel cases by means of a melamine impregnated overlay inserted in the mold during the breathing or degassing cycle. The overlay, a paper-like disc, is printed on the underside and the decoration is protected by a hard glassy melamine surface after it is bonded to the plastic. Except for the design, the overlay disc is colorless and is invisible in the finished product.

Porcelain Pipe Welding Process

A porcelain enamel coated insert of light gage metal has been developed which permits welding porcelain enamel pipe in field operations. By reducing the amount of pre-engineering and prefabrication that ordinarily accompanies installations using porcelain or glass lined pipe, the costs of installed systems can be reduced, and the possible field of application of porcelain lined pipe may be extended considerably. The porcelain coated insert has solved the basic problem of joining standard 21-ft lengths of pipe coated inside and out with porcelain enamel with-

Pedestal Poles and Base Covers made from **Cold-Formed Shapes**



In making these sturdy, long-lasting sign supports, we cold-form tapered channels 12 ft long from 10-gage sheets, then machine-weld the two channels together to form the rectangular pole.

The base cover is also cold-formed from 10-gage sheet steel. It consists of two halves which are bolted together by means of angle clips welded inside.

Bethlehem is fully equipped to turn out jobs like this in almost any quantity. What's more, these poles are only one of literally hundreds of parts and products we've formed, and in some instances, fabricated for such diverse uses as overhead-door track, guy-wire guards, storage racks and lawn-mower parts.

Bethlehem Cold-Formed Shapes are regular or irregular shapes formed cold from strip, sheet or plate steel. They are uniform in thickness and have a high strength-to-weight ratio. We make them on presses, brakes or rolls, in all gages from 5 to 24.

Perhaps you have an idea which could be developed into a practical, cost-cutting use for cold-formed shapes. Tell us about it. Write direct to us at Bethlehem, Pa., including, if possible, a rough sketch of the part you have in mind.

BETHLEHEM STEEL

BETHLEHEM STEEL COMPANY
BETHLEHEM, PA.

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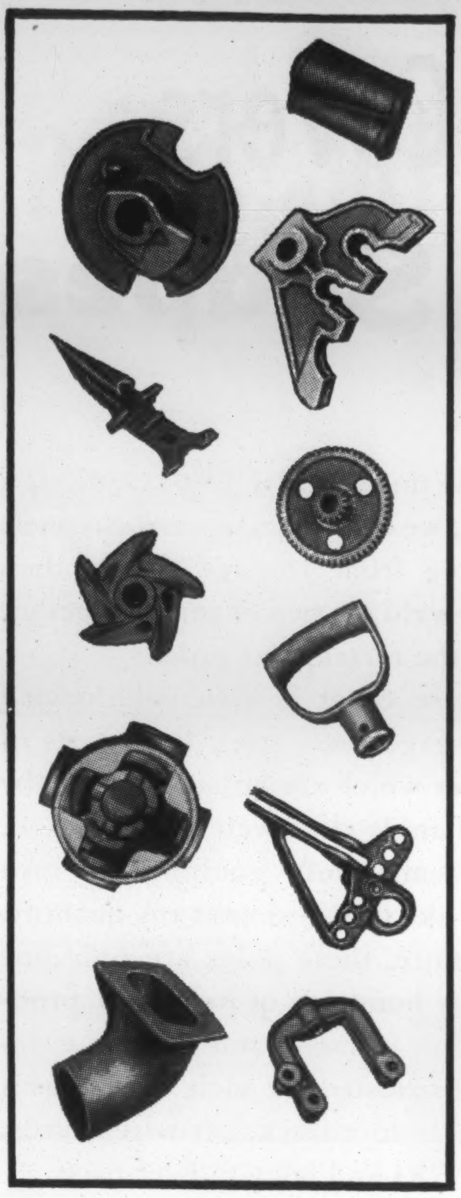

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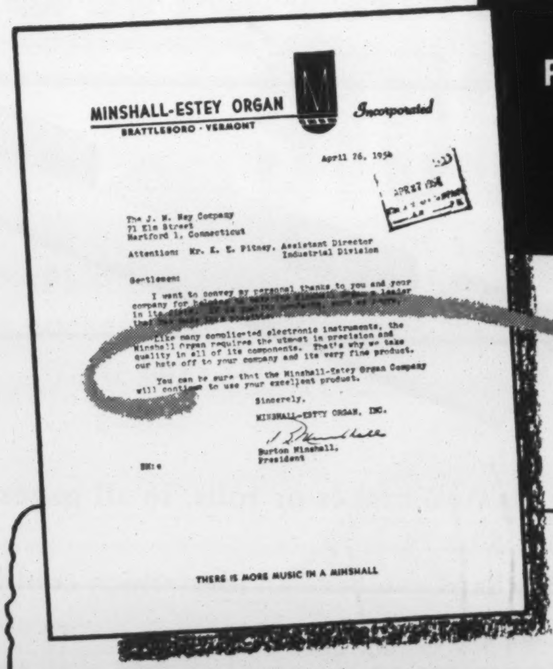

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APR 27 1954

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Attention: Mr. E. E. Pitney, Assistant Director
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Sincerely,

MINSHALL-ESTEY ORGAN, INC.

Burton Minshall,
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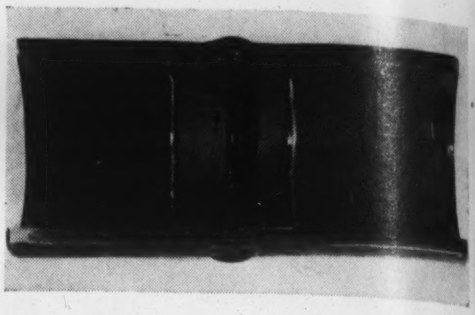
News Digest



Section of oxyacetylene welded porcelain enamel lined pipe, shows insert.

out harming the coating.

In practice the porcelain lined pipe is field cut by any practical method which will provide reasonably square ends. The porcelain enamel insert is put in place and the two pieces of pipe are brought together and welded with a standard oxyacetylene weld. The heat of the welding operation seals the glass coating of the insert to the lining of the pipe, and effectively protects the welded joint from the pipe contents.

The procedure of welding the porcelain pipe is virtually identical with standard pipe welding operations. A good pipe welder can handle the joint in a little longer time than is required for ordinary pipe.

The joining process, developed by the Barrows Porcelain Enamel Co. should eliminate a large amount of custom building and prefabrication in porcelain pipe applications. It will lower the cost of installation, and permit porcelain enameled pipe to be used more economically in such applications as salt water conduit, heat exchanger tubes and other high temperature and corrosive applications.

Aluminum Shipments

Shipments of aluminum forgings, pressings and impact extrusions in 1953 showed an increase of 20% over the shipments of the previous year, according to a joint release by the Business and Defense Services Administration and the Bureau of the Census, Department of Commerce. Total shipments last year amounted to 113.3 million lb, an increase of 19.1 million tons over 1952 shipments.

Consumption of forging stock used by forging plants in the production of aluminum forgings, pressings and impact extrusions totalled 152 million pounds in 1953, which is 13% greater than the 135.5 million lb consumed in 1952. A better ratio of

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Chromel, however, is only one of many specialized, quality-controlled alloys developed and produced by Hoskins. Others include: Alloy 502 . . . used throughout industry for a wide range of heat resistant mechanical applications. Spark plug electrode alloys . . . which have become universally accepted standards of quality and durability. Alloy 717 . . . used in facing engine valves for longer life and improved service. And, of course, there are Hoskins Chromel-Alumel thermocouple alloys for industrial furnaces and jet engines . . . unconditionally guaranteed to register true temperature-e.m.f. values within close specified limits.

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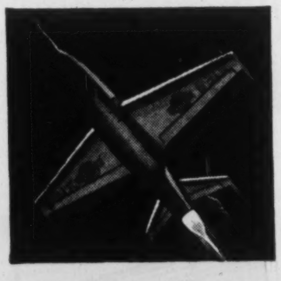

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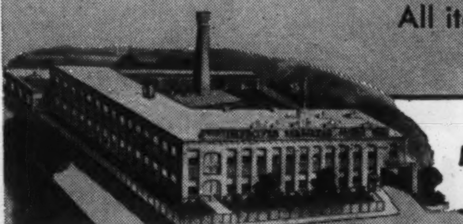

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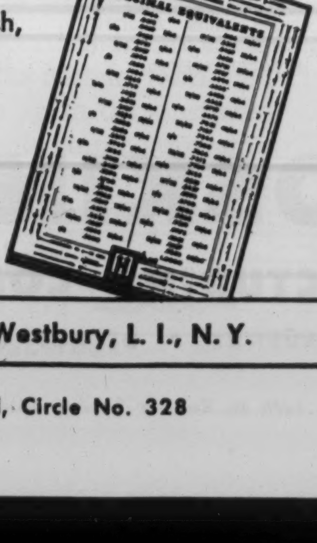

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consumption to shipments was recorded in 1953 than in 1952, also. In 1953 the ratio of forging stock consumed to finished product shipments was 1.348, while it was 1.440 in 1952. Data for collapsible tubes are not contained in this report.

Automation Terms To Be Standardized

The field of automation, automatization, or automatic control, like all specialized fields, is developing its own terminology. Since control techniques cross many specialties such as tool design, electronics, materials handling, information theory, and so forth, the language and terminology used to describe the field contains a great many confusing duplications and double meanings. The American Standards Association recently passed a resolution to develop a standard terminology concerned with automatic control, which will result in better communication within the field.

The ASA elected the American Society of Mechanical Engineers, which has been engaged with the American Institute of Electrical Engineers in terminology research concerned with automatic control for the past ten years, to provide administrative leadership as sponsor of the project.

A committee under the auspices of the American Standards Association will carry out the project, which will be called "Terminology for Automatic Controls."

The Association was asked to initiate the project by ASME, who advised:

"The magnitude of the work already accomplished jointly by ASME and AIEE as well as the growing interest in the broad field of automatic control seems to establish the need for the organization of an ASA Sectional Committee in this field . . . [the ASME recommends] that a project be established under the American Standards Association with a view for a national standard terminology."

Organizations attending a general conference which recommended the project were: American Society of Mechanical Engineers; U. S. Navy, Bureau of Ships; Instrument Society

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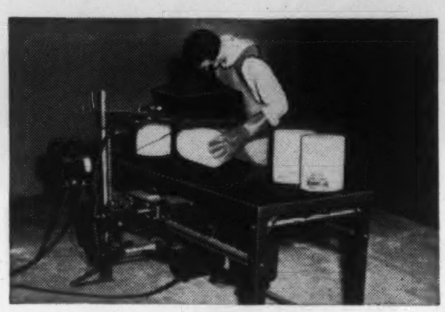

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of America; American Society for Testing Materials; National Bureau of Standards; Institute of Radio Engineers; Chemical Industry Advisory Board; American Petroleum Institute, Scientific Apparatus Manufacturers Association; National Electrical Manufacturers Association; U. S. Department of Defense; and the American Institute of Electrical Engineers.

ASTM Approves 65 New Standards

Featured by 36 technical sessions at which were presented 110 technical papers covering various aspects of engineering materials, the 1954 Annual Meeting of the American Society for Testing Materials, held throughout the week of June 13 at Chicago, also included 600 meetings of the technical committees.

Seventy-two of the Society's technical committees reported at the meeting, with the result that 65 new specifications and tests were approved and revisions in 229 existing tentatives and standards were acted on. A total of 109 specifications and tests that have been published previously as tentative were approved for reference to Society letter ballot for adoption as standard. All of these new and revised standards will be published later in the year in the 1954 Supplement to the Book of ASTM Standards.

Including the 1954 Annual Meeting actions there are now about 2120 ASTM Standards. This compares with the figure twenty years ago of 730 and ten years ago, 1944, of about 1280. These figures indicate a definitely increased tempo in standardization activities during the last decade.

1954 Directors Report

In its Annual Report the ASTM Board of Directors noted that over 6000 technical men now serve on the many hundreds of ASTM technical committtees and subcommittees with the number of working groups now approaching the 2000 mark.

The report noted that the Society has over 2000 specifications, test methods, definitions, etc., and in considering the large number of publications sponsored by technical com-

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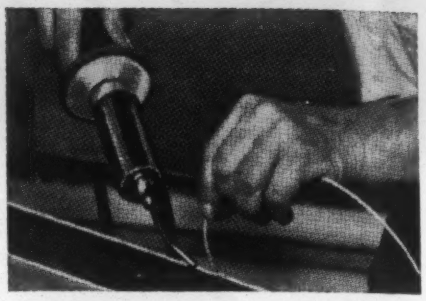

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Making Solder Still More Efficient

Now, new alloys and new soldering techniques are making tin solders still more useful on production lines.

A solder of tin-indium, for example, is now used for sealing glass to metal or glass to glass—will adhere to mica, quartz, thermosetting plastics, and some glazed ceramics, as well.

For joining aluminum, cerium added to a tin-rich, tin-zinc solder gives both improved salt spray resistance and better wettability.

New techniques for applying solder include ultrasonic methods of soldering and tinning aluminum, and the new mechanized dip soldering process that is saving industry thousands of man-hours.

Tin is, of course, the key ingredient in solder. Over one-third of the world's tin is mined and smelted in Malaya. Known as Straits Tin, this metal is more than 99.87% pure and is world-famous for its absolute reliability of grade.

A New Look at Straits Tin

Today, not only new solders but new tin alloys, new tin-alloy coatings and platings, and new uses for tin chemicals have been discovered that make Straits Tin more valuable than ever to American industry. And continuing research will find still more ways in which tin can serve you in the near future.

Whatever your product or process may be, now is the time to reappraise carefully the unique combination of properties of Straits Tin. For no other metal we know today can do so many different kinds of jobs so economically and so well.

MALAYAN TIN BUREAU

A new booklet, "Straits Tin: A Most Useful Metal for American Industry," tells a factual and intriguing story of the many new ways tin can be used today. A copy is yours for the asking.

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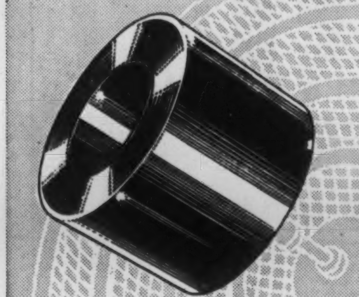

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News Digest

mittees, one realizes the diversity and complexity of ASTM technical work.

Membership during the year passed the 7600 mark. The current annual operating budget is about $720,000.

Committee Actions

The following tentatives and standards were approved in committee and have been submitted to the general membership of the ASTM for approval by letter ballot. The list includes only those actions related to the fields of product manufacturing materials such as metals and plastics.

Adoption of Tentatives as Standard

Committee A-1 for Steel

Spec. for Open-Hearth Steel Girder Rails of Plain, Grooved, and Guard Types (A 2—49 T)

Spec. for Low-Carbon Steel Joint Bars (A 3—49 T)

Spec. for Structural Nickel Steel (A 8—52a T)

Spec. for Soft Steel Track Spikes (A 65—49 T)

Spec. for Steel Screw Spikes (A 66—49 T)

Spec. for Structural Silicon Steel (A 94—52 T)

Spec. for Structural Steel for Locomotives and Cars (A 113—52 T)

Spec. for Carbon Steel Forgings for General Industrial Use (A 235—52 T)

Spec. for Alloy Steel Forgings for General Industrial Use (A 237—52 T)

Spec. for Carbon and Alloy Steel Ring and Disk Forgings (A 243—51 T)

Spec. for Carbon Steel Seamless Drum Forgings (A 266—51 T)

Spec. for Low and Intermediate Tensile Strength Carbon-Steel Plates of Structural Quality (Plates 2 in. and Under in Thickness) (A 283—52 T)

Spec. for Carbon and Alloy Steel Forgings for Magnetic Retaining Rings for Turbine Generators (A 288—50 T)

Spec. for Alloy Steel Forgings for Nonmagnetic Coil Retaining Rings for Turbine Generators (A 289—52 T)

Spec. for Carbon and Alloy Steel Forgings for Rings for Reduction Gears (A 290—52 T)

(Continued on page 254)

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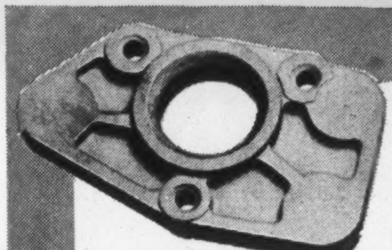

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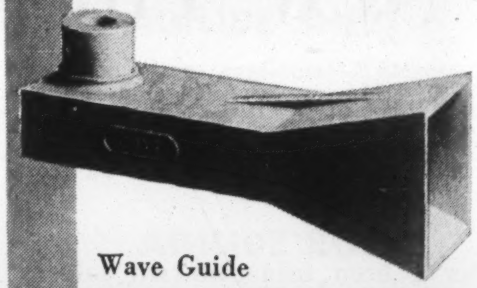
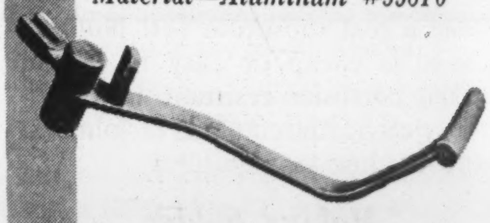


Wave Guide
Material—Aluminum #356T6



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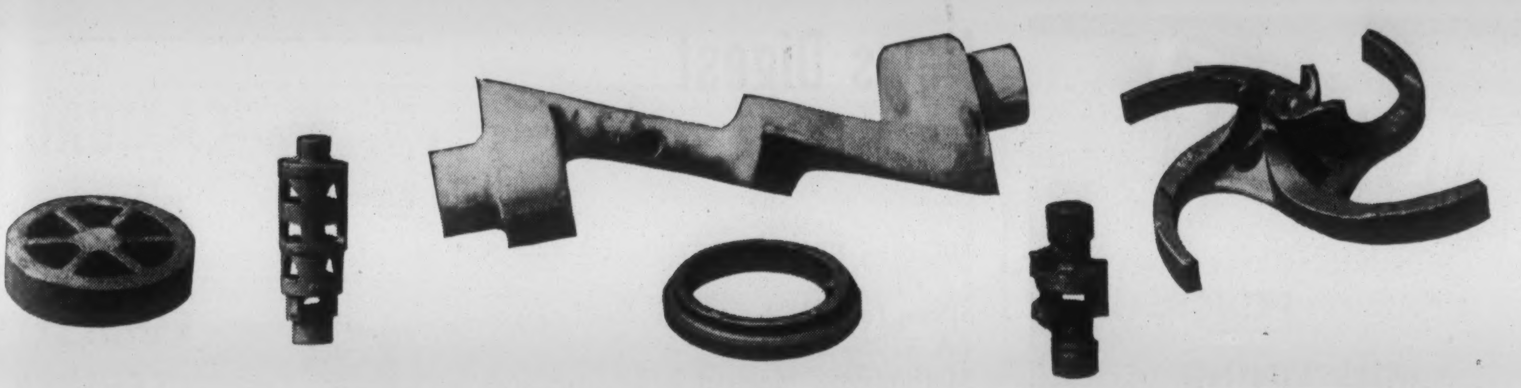

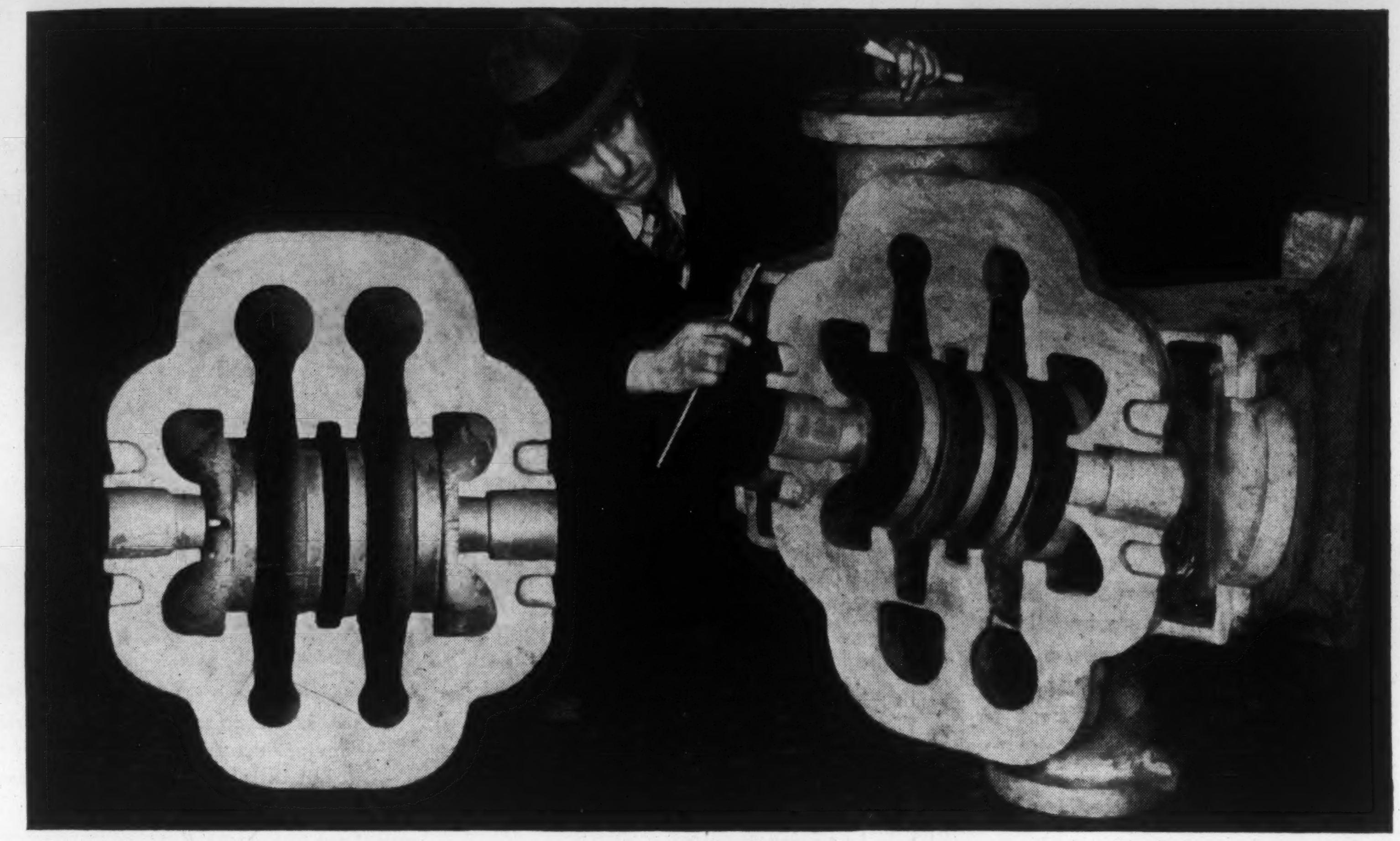

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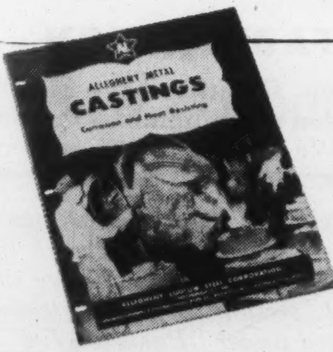

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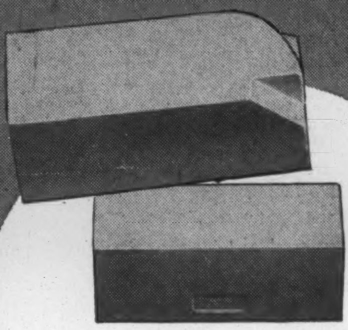

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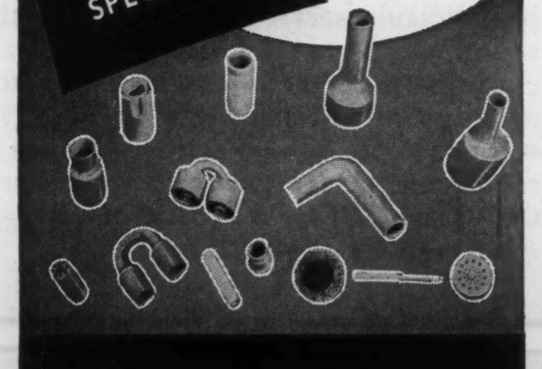

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News Digest

Spec. for Steel Sheet Piling (A 328—52 T)
Spec. for Heat-Treated Steel Tires (A 329—50 T)
Methods of Macroetch Testing and Inspection of Steel Forgings (A 317—52 T)
Spec. for Medium-Carbon Steel Joint Bars (A 4—49 T)
Spec. for Carbon Steel Forgings for Locomotives and Cars (A 236—52 T)
Spec. for Alloy Steel Forgings for Locomotives and Cars (A 238—49 T)
Spec. for Carbon Steel Blooms, Billets, and Slabs for Forgings (A 273—52 T)
Spec. for Alloy Steel Blooms, Billets, and Slabs for Forgings (A 274—52 T)
Spec. for Carbon and Alloy Steel Forgings for Pinions for Reduction Gears (A 291—52 T)
Spec. for Carbon and Alloy Steel Forgings for Turbine Generators Rotors and Shafts (A 292—52 T)
Spec. for Carbon and Alloy Steel Forgings for Turbine Bucket Wheels (A 294—52 T)

Committee A-3 for Cast Iron
Methods of Impact Testing of Cast Iron (A 327—50 T)

Committee A-5 for Corrosion of Iron and Steel
Test for Local Thickness of Electrodeposited Coatings (A 219—51 T)

Committee A-7 for Malleable-Iron Castings
Spec. for Malleable Iron Flanges, Pipe Fittings, and Valve Parts for Railroad, Marine, and other Heavy Duty Service (A 338—51 T)

Committee A-10 for Iron-Chromium, Iron-Chromium-Nickel, and Related Alloys
Spec. for Hot-Rolled and Cold-Finished Corrosion-Resisting Steel Bars (A 276—49 T)

Committee B-5 for Copper and Copper Alloys, Cast and Wrought
Spec. for Cartridge Brass Sheet, Strip, Plate, Bar, and Disks (B 19—52 T)
Spec. for Copper-Base Alloy Centrifugal Castings (B 271—52 T)
Rec. Practice for Tension Test Specimens for Copper-Base Alloys for Sand Castings (B 208—49 T)

(Continued on page 256)

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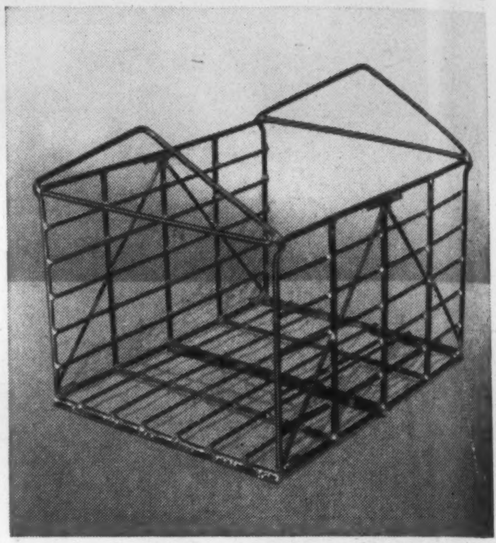

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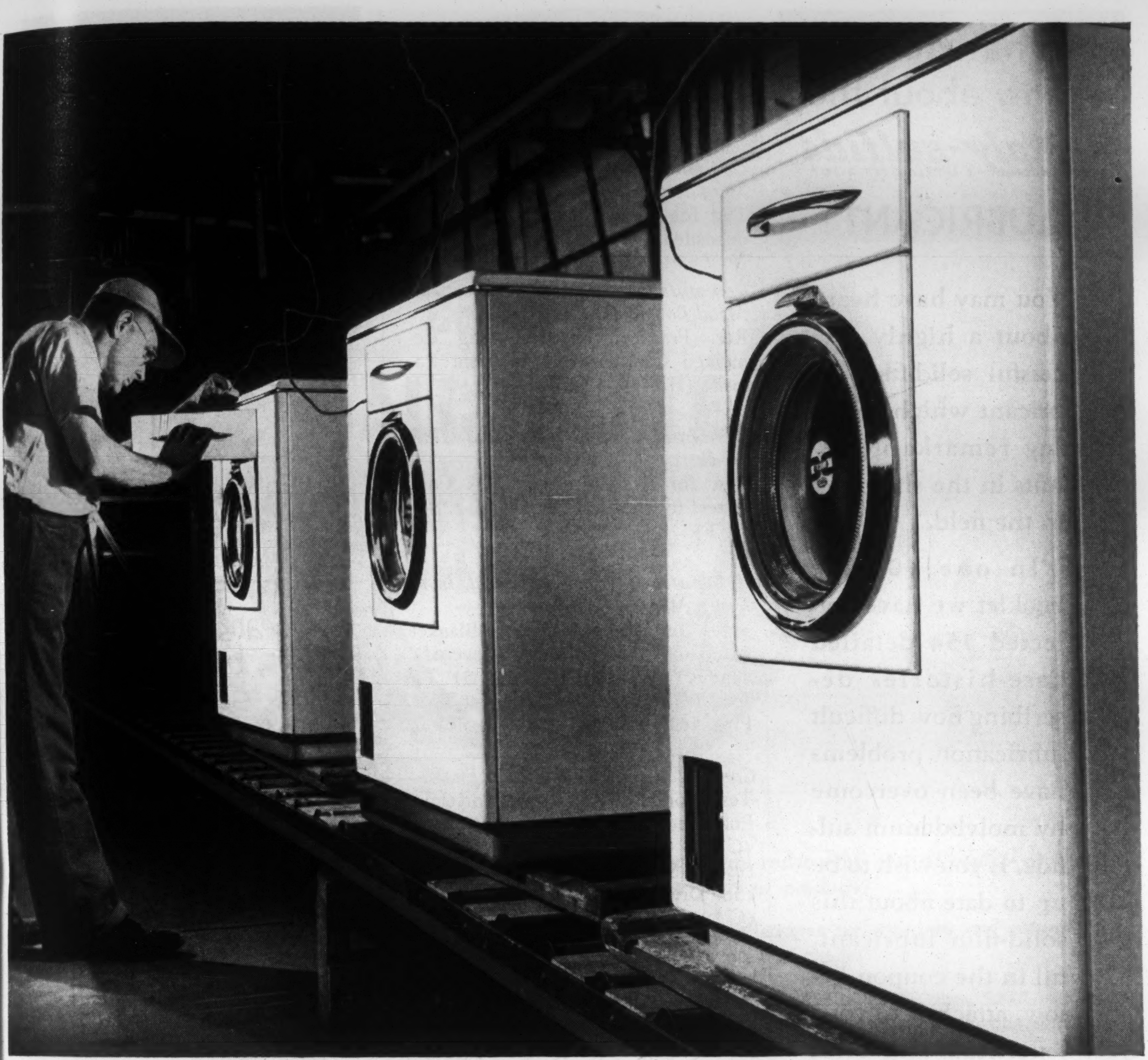

How Fosbond helps make Caloric Dryer a beautiful buy

The new Caloric Gas Clothes Dryer has to have an unusually durable finish both inside and out—one that will stay like-new for years, in spite of extreme and regular exposure to moisture and heat.

To help Caloric meet these high requirements, Pennsalt specialists made a comprehensive plant survey. Working closely with Caloric production men, they devised a Fosbond cycle for use on dryer parts prior to final finishing with Glidden's Nu-Pon. Fosbond 10, a zinc phosphate solution for spray application, was selected as the phosphatizing agent.

The Fosbond® Process provides lifetime corrosion resistance and creates an ideal surface for an organic finish —making it easier to apply, and promoting a smoother coating firmly "locked" to the base metal. In addition to the necessary materials, Pennsalt offers *continuing* technical assistance to keep the Process smooth-running, trouble-free. And behind Fosbond stands Pennsalt—a major chemical producer with long experience in the metal processing field.

If your plant and product would benefit from a *better* phosphatizing process and the merchandising value of the Fosbond-Good Housekeeping emblem, you ought to know more about Fosbond. Let us make a survey of your finishing operation (takes but a few hours . . . no obligation). Write: Customer Service Dept., Pennsylvania Salt Manufacturing Co., 848 Widener Bldg., Philadelphia 7, Pa.

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Pennsalt Chemicals

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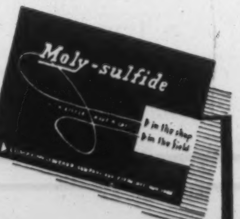

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News Digest

Committee B-8 for Electrodeposited Metallic Coatings
Test for Local Thickness of Electrodeposited Coatings (A 219—51 T)

Committe B-9 for Metal Powders and Metal Powder Products
Rec. Practice for Evaluating Cemented Carbides for Apparent Porosity (B 276—52 T)

Committee C-14 for Glass and Glass Products
Test for Resistance of Glass Containers to Chemical Attack (C 225—49 T)

Committee C-16 for Thermal Insulating Materials
Spec. for Mineral Wool Blanket Insulation (Metal-Mesh Covered) (Industrial Type) (C 263—51 T)
Spec. for Mineral Wool Blanket-Type Pipe Insulation (C 280—51 T)

Committee C-22 for Porcelain Enamel
Test for Resistance of Porcelain Enameled Utensils to Boiling Acid (C 283—52 T)
Test for Sieve Analysis of Wet Milled and Dry Milled Porcelain Enamel (C 285—52 T)

Committee D-1 for Paint, Varnish, Lacquer, and Related Products
Water Immersion Test of Organic Coatings on Steel (D 870—51 T)
Laboratory Test for Degree of Resistance of Traffic Paint to Bleeding (D 969—52 T)
Test for Color of Clear Liquids (Platinum-Cobalt Scale) (D 1209—52 T)
Methods for Measurement of Wet Film Thickness of Paint, Varnish, Laquer, and Related Products (D 1212—52 T)
Test for Crushing Resistance of Glass Spheres (D 1213—52 T)
Test for Sieve Analysis of Glass Spheres (D 1214—52 T)

Committee D-6 for Paper and Paper Products
Test for Water Resistance of Paper, Paperboard, and Other Sheet Materials by the Dry-Indicator Method (D 779—52 T)
Test for Ply Adhesion of Paper (D 825—52 T)

Committee D-9 for Electrical Insulating Materials
Spec. for Natural Block Mica and

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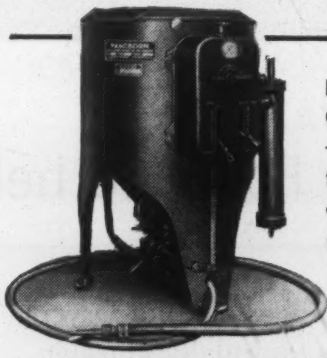

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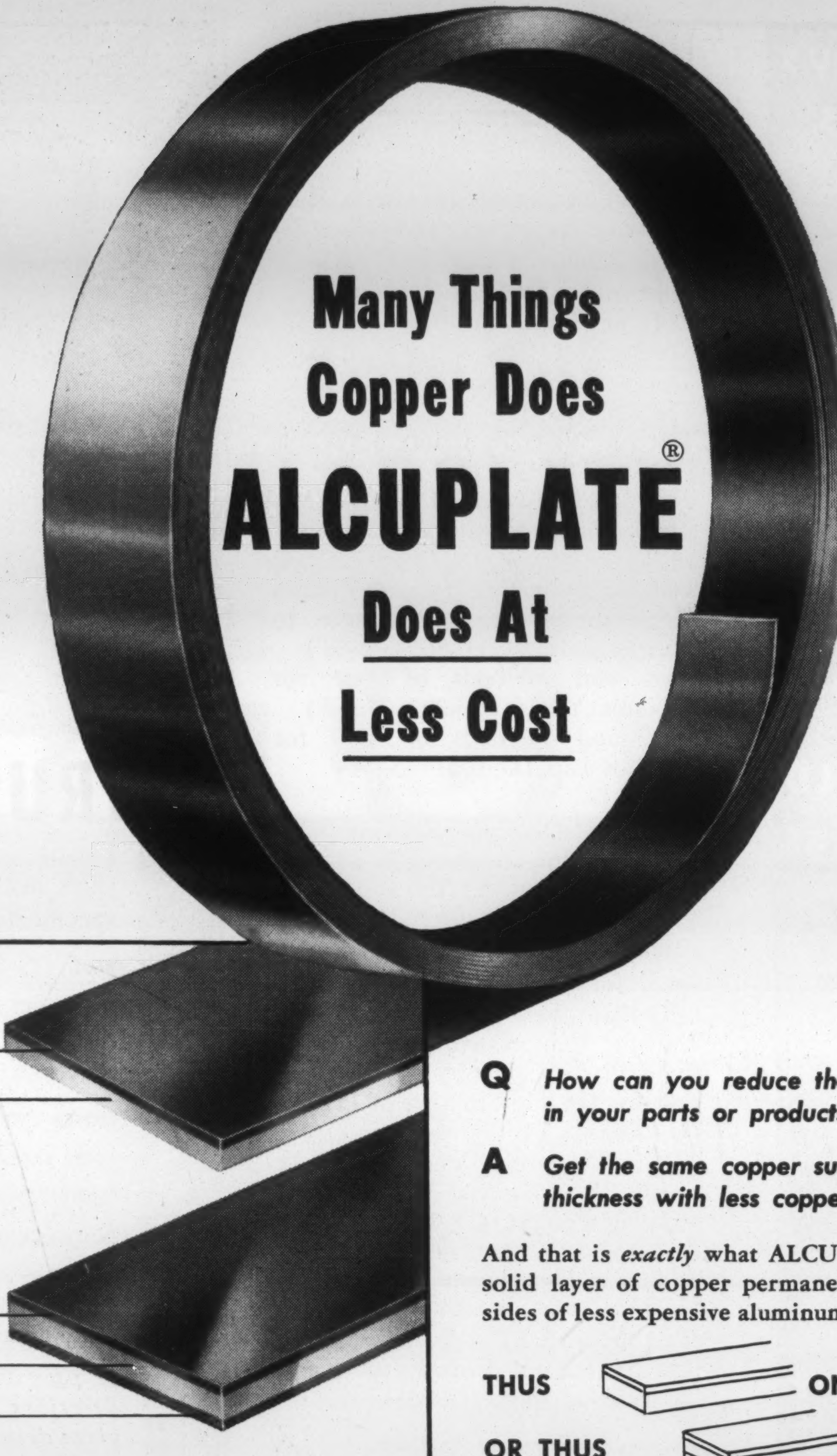

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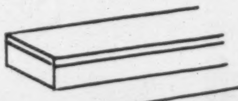
THUS  **ON ONE SIDE**

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News Digest

Mica Films Suitable for Use in Mica-Dielectric Capacitors (D 748—52 T)

Committee D-13 for Textiles
Def. of Terms Relating to Textile Materials (D 123—53 T)
Test for Colorfastness to Light of Textiles (D 506—52 T)
Test for Water Resistance of Textile Fabrics (D 583—52 T)
Test for Resistance of Textile Materials to Microorganisms (D 684—53 T)
Test for Evaluating Treated Textiles for Permanence of Resistance to Microorganisms (D 862—45 T)
Spec. and Methods of Test for Asbestos Yarns (D 299—52 T)
Spec. and Methods of Test for Asbestos Lap (D 1061—52 T)

Committee D-14 for Adhesives
Spec. for Impact Strength of Adhesives (D 950—52 T)

Committee D-20 for Plastics
Spec. for Primary Octyl Phthalate Ester Plasticizers (D 1249—52 T)
Test for Compressive Properties of Rigid Plastics (D 695—52 T)
Test for Bearing Strength of Plastics (D 953—48 T)
Test for Apparent Density and Bulk Factor of Granular Thermoplastic Molding Powder (D 1182—51 T)
Test for Measurement of Changes in Linear Dimensions of Nonrigid Thermoplastic Sheeting or Film (D 1204—52 T)
Test for Specific Viscosity of Vinyl Chloride Polymers (D 1243—52 T)

(Continued on page 260)

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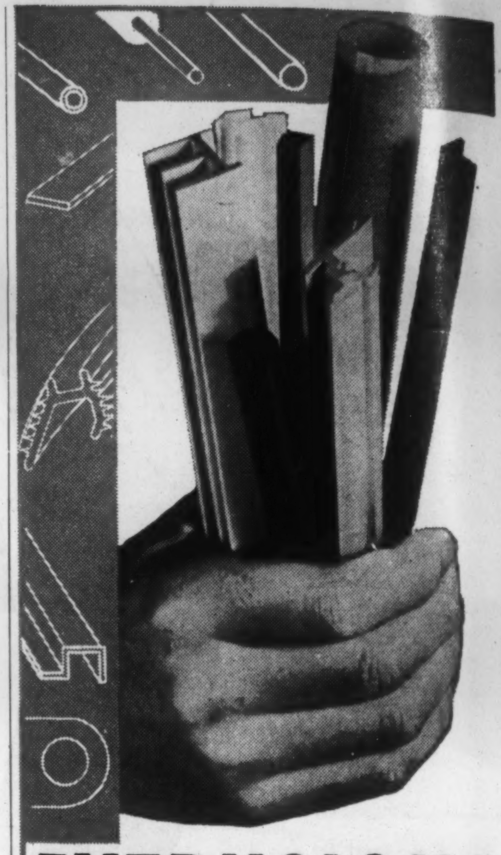

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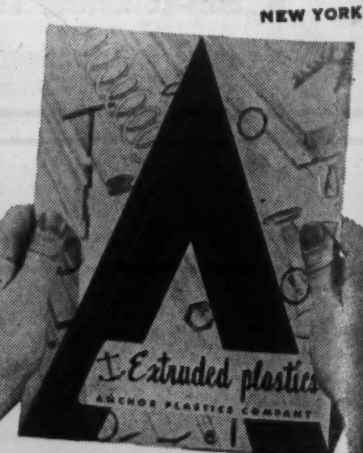

For more information, Circle No. 527